Report of Faculty of Fisheries,
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A New Blenioid Fish from Japan

(With 1 Text-figure and 1 Table)

YAICHIRO OKADA and KIYOSHI SUZUKI
Faculty of Fisheries, Prefectural University of Mie

The genus *Eulophias* has been established in 1901 by H. M. SMITH for the accommodation of his new species, *E. tanneri*, which had been taken from deep water of Suruga Bay, and since then no other species of the present genus has been recorded in any part of the world. In November, 1952, the present authors obtained a curious blenioid fish belonging to the genus *Eulophias*, which had been taken by the motor trawler from deep water off Owashi, Mie Prefecture. Upon careful examination, it proved to represent a new species, which described herein a *Eulophias owashii*.

Eulophias owashii, n. sp.

Description: The holotype (Specimen No. 4494 in Faculty of Fisheries, Prefectural University of Mie) is 173 mm. in standard length (178 mm. in total length), having the following counts and measurements: D. 139 (127 spines and 12 soft rays); A. I, 95; P. 7; C. 10. Head 9.61 in standard length; depth 21.63; distance from tip of lower jaw to the origin of anal 2.79; same from tip of lower jaw to anus 2.98; same from tip of upper jaw to origin of dorsal 9.61; trunk 4.34; tail (distance from vent to base of caudal) 1.52. Eye 3.6 in head; snout 6; upper jaw 3.6; interorbital space 4.5; width of head 2; pectoral 3.6.

Body eel-like in shape, rounded anteriorly, but compressed posteriorly and depth nearly uniform throughout entire length of body. Head short, slightly depressed nearly as wide as deep; snout short and blunt; eye high up, the upper rim entiring upper profile of interorbital space which rather convex. Mouth oblique; maxillary reaches to a vertical through middle of eye.

Gill membranes continuous, free from the isthmus, forming a broad fold across it.

Dorsal inserted somewhat before the posterior margin of opercular flap, extending toward the caudal fin, and gradually increasing in height from before backward. Anal fin begins under the thirty-sixth dorsal spine. Anal spine subequals to half of the length of neighbouring soft ray. Along the upper and lower margin, caudal fin blended with the posterior parts of dorsal and anal. Pectoral fin rather short, rounded, equals to horizontal diameter of eye, inserted

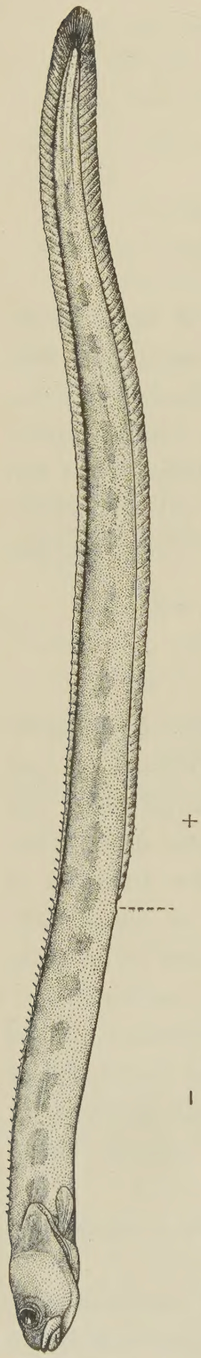


Fig. 1. *Eulophias owashii*, n. sp. (×2/3)

close to isthmus, distance from the anterior end of upper jaw to the upper edge of the base of pectoral 1.13 in head. No ventrals.

Color in formalin the body light greyish, the lateral side with 24 dark brown blotches along the entire length of body.

Remarks: The present species has close resemblance in general appearance to *Eulophias tanneri*, but differs from it in several characteristics as shown in the following table.

Table 1

Species / Characteristic	*Eulophias owasii*, n. sp.	*Eulophias tanneri*
Anal fin	1 spine 95 soft rays	1 spine 75 soft rays
Caudal fin	10 rays	7 rays
Pectoral fin length	3.6 times into head.	2.8 times into head.
Distance from anterior edge of lower jaw to origin of anal.	2.8 times into standard length.	2.52 times into standard length.

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The Osteological Study of the Genus *Malakichthys*

(*With 5 Text-figures*)

YAICHIRO OKADA and KIYOSHI SUZUKI
Faculty of Fisheries, Prefectural University of Mie

Three species, *Malakichthys griseus* STEINDACHNER and DÖDERLEIN, *M. wakiyae* JORDAN and HUBBS, and *M. elegans* MATSUBARA and YAMAGUCHI have been recognized as the representatives of the genus *Malakichthys*.

The taxonomic study of these three species was accomplished by MATSUBARA and YAMAGUCHI (1943) together with the original description of *M. elegans*. After careful examination, they pointed out that each of these fishes is distinct, although FOWLER (1930) and TANAKA (1931) considered *M. wakiyae* as a synonym of *M. griseus*. But KURODA (1947) noted that some differences between *M. griseus* and *M. wakiyae* are not referable to the result of specific distinction and considered them to be two forms of the same species, but *M. elegans* is distinguishable from the two other species upon the comparison of the external characters.

The object of the present work is to make comparative studies on the osteology of the three species in order to review their systematic relationships. These investigations were made upon two specimens of *M. griseus* from Heta, Shizuoka Prefecture; five specimens of *M. wakiyae* from Owashi, Mie Prefecture; and five specimens of *M. elegans*, three young specimens of this species from Kochi, Kochi Prefecture, the other adult specimens from Owashi, Mie Prefecture.

For the two *M. griseus* from Heta and three young *M. elegans* from Kochi, the authors are indebted to Dr. KURODA and Prof. KAMOHARA of Kochi University.

I Cranium

(Fig. 1, Fig. 2)

A striking contrast of the shape of the cranium separates *M. wakiyae* from the other species. But the element composing the cranium and arrangement are essentially the same in these three species. Anteorbital portion of the cranium.

Vomer is an unpaired bone, situated at the anterior part of the cranium. It is bounded dorso-posteriorly by the ethmoid and prefrontals. The ventral process forms a part of the ventral surface of the cranium. The irregularly arranged villiform teeth are present on the anterior part of the ventral surface.

The ethmoid is next to the vomer. It is bounded dorso-anteriorly by the vomer, dorso-posteriorly by the frontals, laterally by the prefrontals, and ventrally

by the process of the vomer and parasphenoid. The ethmoid process projects anteriorly from the meeting point of the frontals.

The prefrontals are lateral to the ethmoid and anterior to the frontals. Each has a broad base-like portion and wing-like process projecting from it which forms the anterior boundary of the orbit.

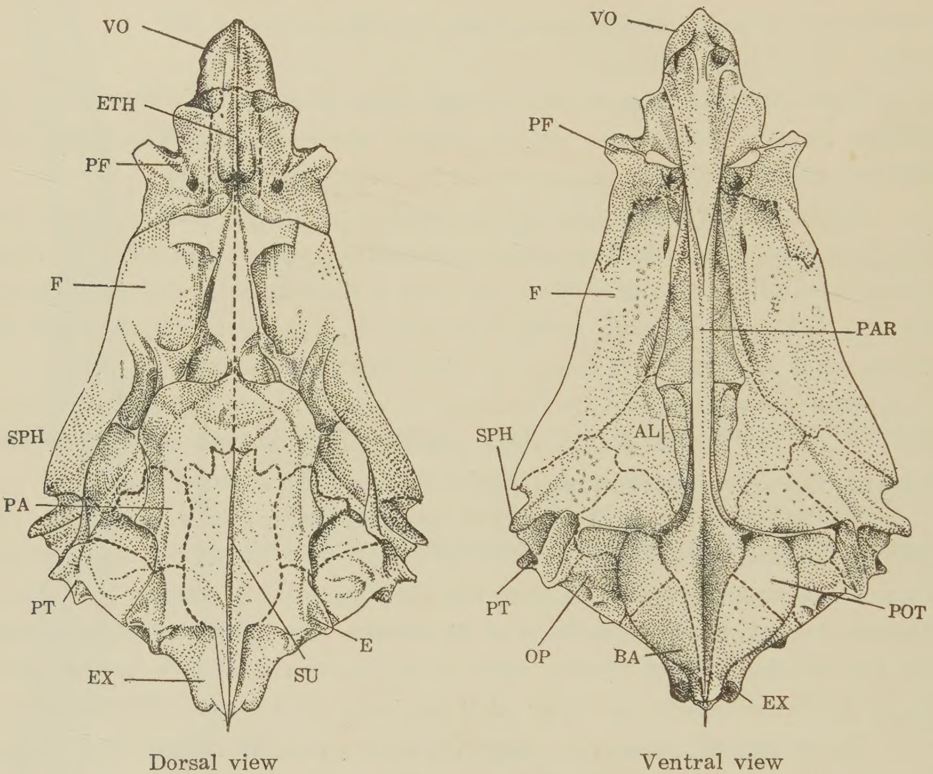


Fig. 1 (A). Cranium of *Malakichthys wakiyae*. ×3

Abbreviations

AL,	alisphenoid	HYO,	hypocoracoid
AN,	angular	IH,	interhyal
AR,	articular	OP,	opisthotic
BA,	basioccipital	PA,	parietal
BR,	branchiostegal ray	PAR,	parasphenoid
BAS,	basisphenoid	PC,	postclavicle
CE,	ceratohyal	PF,	prefrontal
CL,	clavicle	POT,	prootic
D,	dentary	PT,	pterotic
E,	epiotic	PTT,	post-temporal
EP,	epihyal	SC,	supraclavicle
ETH,	ethmoid	SPH,	sphenotic
EX,	exoccipital	SU,	supraoccipital
F,	frontal	UH,	urohyal
HH,	hypohyal	VO,	vomer
HYP,	hypercoracoid		

The frontals cover the greater part of the dorsal surface of the cranium. In *M. wakiyae*, the shape of the frontal in dorsal view is distinguishable from the two other species. In the case of the frontals of *M. wakiyae* the deep sensory canal is placed longitudinally on either side of the median suture. The laminar and somewhat high pterotic crest runs forward to the position corresponding to about the one-third of the length of the frontals. The anterior end of this crest

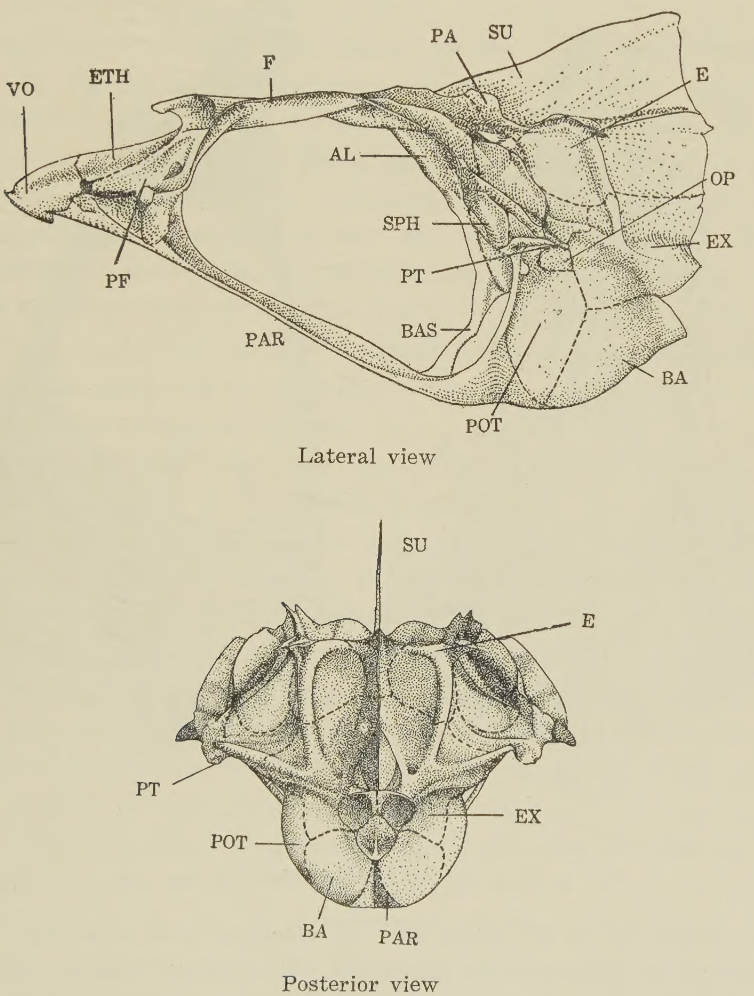


Fig. 1 (B). Cranium of *Malakichthys wakiyae*. ×3

is bifurcated into two branches. One crest is the narrow and small crest situated between the pterotic crest and the dorsal surface of the cranium, and the other branch passes inward perpendicular to the pterotic crest, and connects with the temporal crest passing forward from the parietal to the frontals. After reaching the position corresponding to one-half of the length of the frontal, the temporal

crest bends inward reaching near the origin of the supraoccipital crest. There is a triangular bridge connecting the bending point of the temporal crest, the dorsal surface of the frontal, and the posterior end of the lower crest passing from the attachment of the ethmoid process.

In the anterior part of the frontal, the narrow bridge crosses the sensory canal from the attachment of the ethmoid process to the dorsal surface of the

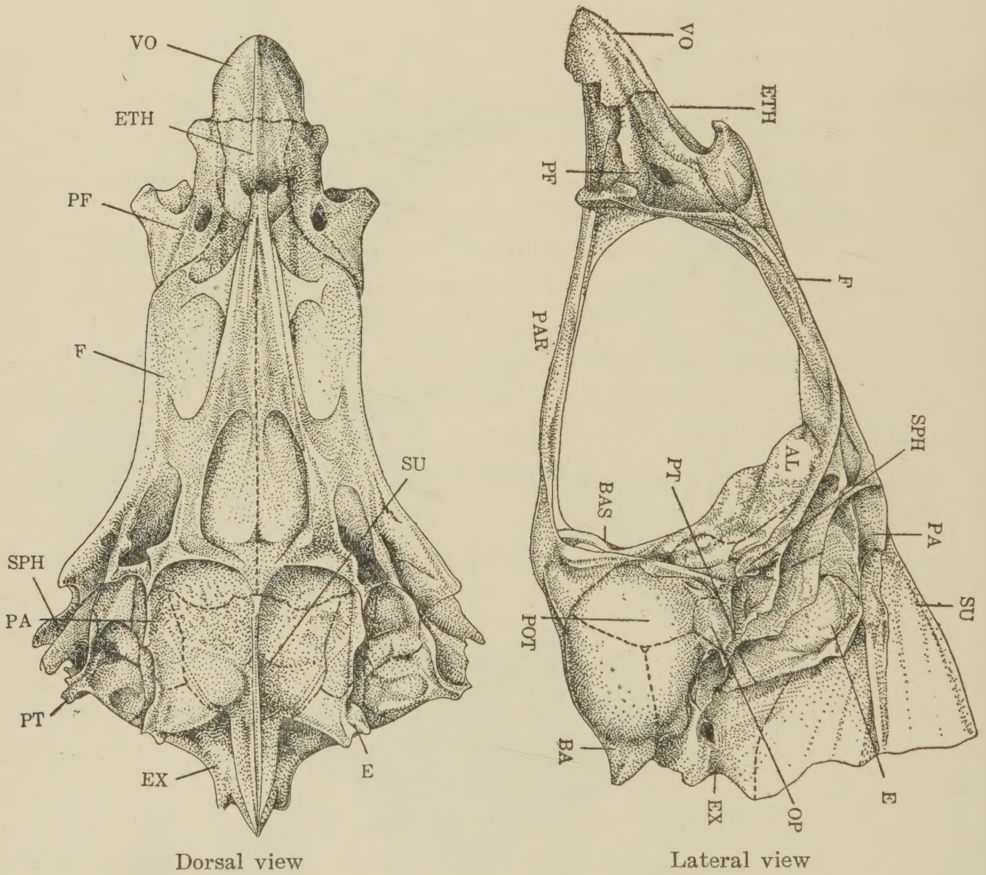


Fig. 2. Cranium of *Malakichthys elegans*. ×3

frontal. In the case of *M. griseus* and *M. elegans*, some differences from the above-mentioned characters are recognized. The pterotic crest is lower than in the case of *M. wakiyae*. This crest diverges at the position corresponding to one-seventh of the lower part of the frontal. One branch crosses the sensory canal and reaches to the dorsal surface of the frontal. The other branch bends inward perpendicular to the pterotic crest and connects with the temporal crest. The temporal crest curves bluntly toward the median suture between the frontals, and yet it is inclined posteriorly at the curving portion. The shape of the bridge connecting the curved portion of the temporal crest, the dorsal surface of the

frontal and the posterior end of the lower crest passing from the attachment of the ethmoid process differs from the case of *M. wakiyae*. In *M. griseus* and *M. elegans* it is narrower and longer.

The parasphenoid is the longest bone situated in the ventral surface of the cranium. The anterior part ot this bone is nearly straight on the ventral surface but the posterior part from the portion articulating with the basisphenoid is curved upward. The opening of the myodome is unrecognized in these three species. Postorbital portion of the cranium.

Regarding the gradient of the dorsal surface of the brain cavity to the frontals, *M. wakiyae* is distinguishable from the other species. Namely, in *M. wakiyae* there is no gradient to the frontals, but in *M. griseus* and *M. elegans*, there is some gradient and the dorsal surface of the brain cavity runs roughly parallel to the line of the anterior portion of the parasphenoid.

The parietals are situated on both sides of the supraoccipital. The bones are surrounded anteriorly by the frontals, posteriorly by the epiotics, on the outer side by the pterotics, on the inner side by the supraoccipital. The parietals have a high longitudinal crest on the dorsal surface. This crest forms a part of the temporal crest, and is continuous to the crest on the frontals anteriorly, and to the epiotic process posteriorly.

The supraoccipital forms the dorso-posterior part of the cranium. It is bounded dorsally by the frontals, parietals, and epiotics, and posteriorly by the epiotics and exoccipitals. The supraoccipital crest is well elongated longitudinally from the lower part of the boundary of the frontals to the posterior end of the cranium. The shape of this bone varies according to the species. In *M. wakiyae*, the origin of the supraoccipital crest is situated at some distance from the anterior end of the temporal crest on either side of the frontals. The crest ascends abruptly from the origin to the posterior end, assumes an acute-angled triangle in the lateral outline. But, in *M. griseus* and *M. elegans*, the origin of the crest is nearly situated at the anterior end of the temporal crest on either side of the frontals. The crest ascends smoothly from the origin to the posterior end, assumes a rightangle in lateral outline.

The epiotics are situated at the dorso-posterior portion of the cranium. Each bone is bounded dorsally by the supraoccipital and parietals, laterally by the sphenotics and pterotics, and posteriorly by the supraoccipital and exoccipitals. Each bone has a prominent epiotic process which is articulated with the dorsal fork of the post-temporal.

The alisphenoids are situated on the ventral sides to the articulating line of the sphenotics and frontals.

The basisphenoid is a Y-shaped bone, situated on the anterior margin of the roof of the myodome. It is articulated dorso-laterally with the alisphenoids

and prootics. The pedicle is curved ventrocephalid to the parasphenoid where it is united to it.

The sphenotics are situated at the margin of the cranium, just posterior to the orbit. The greater part of the dorsal surface of each bone is covered by the frontals. On the ventral surface the bone is articulated anteriorly by the frontals, laterally by the alisphenoid, and posteriorly by the prootics. Each bone has a broad base-like portion and a process-like portion. In the ventro-lateral surface of each bone there is a facet for articulation with the anterior head of the hyomandibular.

The prootics form a large part of the lateral surface of the cranium. Each bone is bounded dorsally by the sphenotics and pterotics, and ventrally by the parasphenoid, anteriorly by the alisphenoids, basisphenoid, and dorso-lateral process of the parasphenoid, and posteriorly by the opisthotics, exoccipitals and basioccipital. The prootics form the lateral walls of the brain-case and the roof and walls of the myodome. Between the brain cavity and the myodome, there is a mesial longitudinal partiation which unites with a similar one from the opposite side at the median line.

The pterotics are situated on the posterior portion of the lateral margin of the cranium. The bones are pointed at the corner and form posteriorly the pterotic process. At the ventro-lateral surface the bones have a facet for the articulation of the posterior head of the hyomandibular.

The opisthotics are small plate-like bones, situated between the pterotics and the exoccipitals. The posterior end of this bone is united by a cartilaginous ligament to the ventral for of the posttemporal.

The exoccipitals are situated at the postero-lateral part of the brain cavity. The lower part of the supraoccipital is inserted between the dorso-posterior part of the exoccipital on both sides, which forms the lateral wall of the foramen magnum.

The basioccipital is a bone with a concave occipital condyle which is articulated with the first vertebra. It is situated at the ventroposterior end of the cranium, forming the posterior end of the myodome.

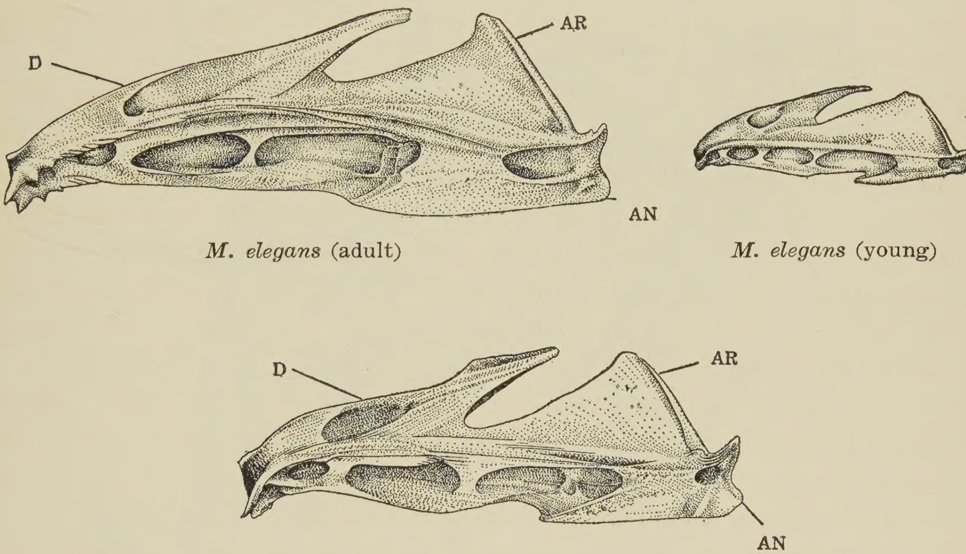
II Mandible

(Fig. 3)

The mandible is consisting of three bones, the dentary, articular and angular. A blunt and broad ridge extends from the head of the articular to the anterior end of the dentary. There is a latero-sensory canal along the ridge.

The dentary is a lateral compressed bone with two long processes at the posterior part. The villiform teeth are irregularly arranged along the dorsal

biting edge. In the adult of *M. elegans* (standard length 154–210 mm) several pungent tooth-like spines, which are directed downward, are exhibited along the ridge and lower edge of the dentary. Although a pair of pungent tooth-like spines are present at the mandibular symphysis, the remainder are not recognized in *M. wakiyae*, *M. griseus* and even the young of *M. elegans* (standard length 94–75 mm.) The arrangement of these tooth-like spines in the adult of *M. elegans*



M. elegans (adult) *M. elegans* (young)

M. wakiyae

Fig. 3. Mandible of *Malakichthys*.

is as follows. Seven tooth-like spines are present on the ridge. The first of these spines, which is situated at the anterior end of the ridge, is directed forward and downward, but the other six spines are directed backward and downward. There are four tooth-like spines on the lower edge of the dentary, the first of which is situated parallel with the first tooth-like spine of the ridge, and other three spines are directed backward and downward.

The articular has a long pointed process which is partly inserted into a V-shaped angle of the dentary. There is an articulation surface with the quadrate on the dorso-posterior part of the bone. The angular is a very small bone, stoutly united to the ventro-posterior part of the articular.

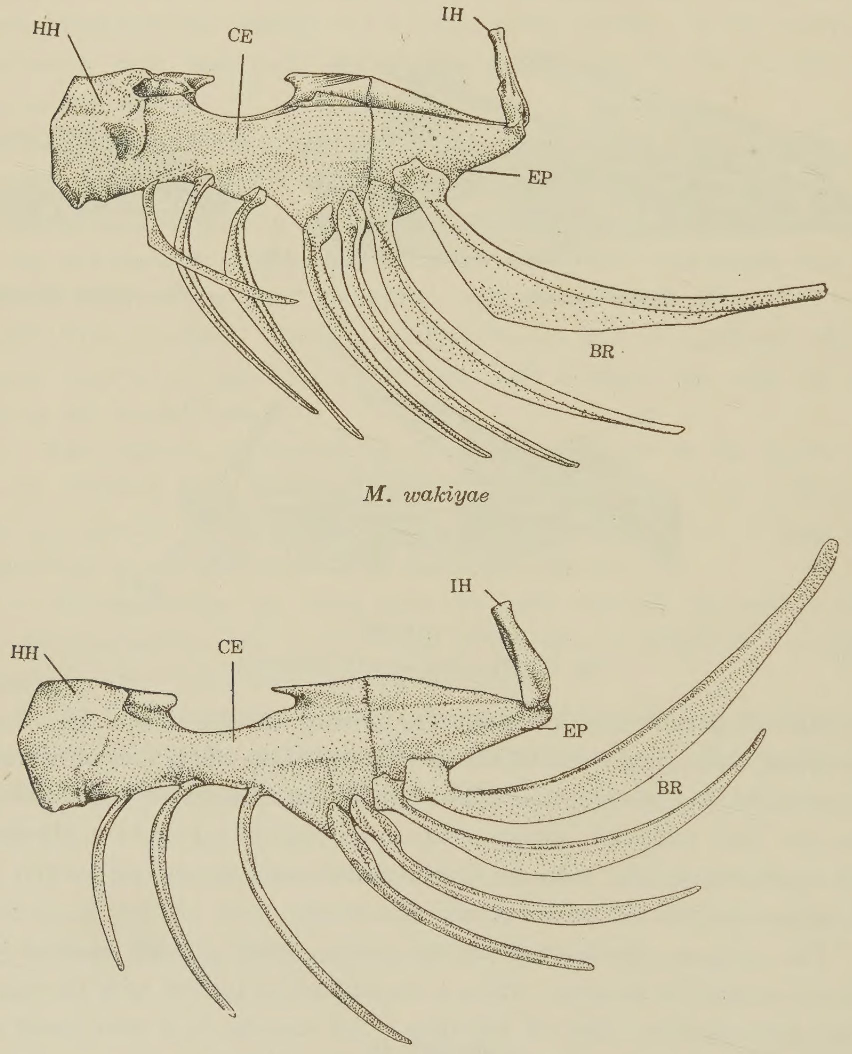
III Hyoid apparatus

(Fig. 4, Fig. 5)

The interhyal is a rod-like bone, articulated in a shallow socks in the dorso-posterior edge of the epihyal. The lower part of this bone is somewhat

bulged in *M. griseus* and *M. elegans*, but in *M. wakiyae* the lower part is not bulged.

The epihyal is a flat, triangular bone. Five anterior branchiostegals are attached to the ventral edge of the bone. There is an oval-like concave portion in the dorsal edge of the bone.



M. elegans

Fig. 4. Hyoid apparatus of *Malakichthys*. ×3

In *M. wakiyae* the ceratohyal is rather shorter and broader than in the others, and the out-line of the concave portion is a regular oval, but an irregular and elongated oval-like form is found in *M. griseus* and *M. wakiyae*

The hypohyals form the symphysis with the corresponding bones of the

other side behind the glossohyal. Each bone is composed of two parts, upon and lower.

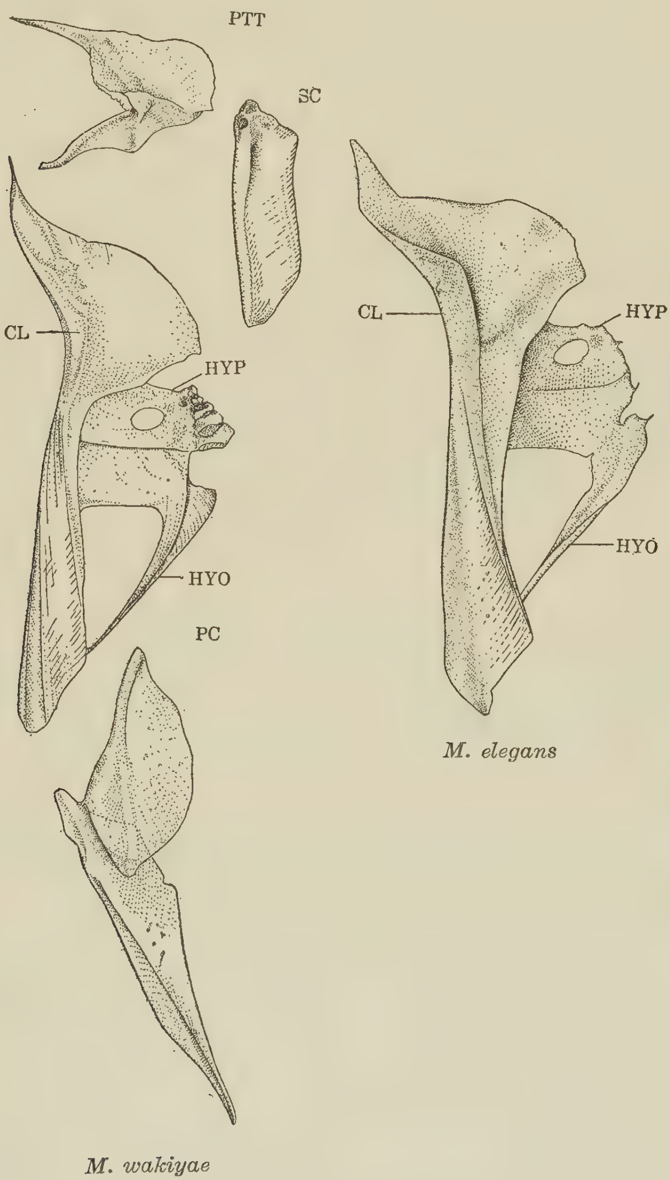


Fig. 5. Shoulder girdle of *Malakichthys*.

The urohyal is a compressed bone gradually widening posteriorly. It is articulated to the hypohyals at the anterior end, but free at the posterior end. The shape of this bone of *M. griseus* is distinguishable from the bones of the two other species. Namely, in *M. griseus*, this bone has a conspicuous and long

process directed dorso-anteriorly at the anterior edge. Moreover this bone has a similar process which is not more conspicuous in *M. wakiyae* and *M. elegans*.

The branchiostegals are flat, slender, curved bones. They are seven in number, and longer broader and more curved posteriorly. In *M. wakiyae* the first of the brnchiostegals is curved angularly, but in *M. griseus* and *M. elegans*, curved smoothly.

IV Shoulder girdle

(Fig. 5)

The post-temporal is a small forked bone. The dorsal branch is attached on the epiotic process, and the ventral branch is articulated to the opisthotic. The posterior margin is laminar and somewhat serrated.

The supraclavicle is an elongated trapezoid bone. The clavicle is a large bone, broad at the dorsal part and narrow and thin at the ventral part. Along the posterior margin of the inferior wing of this bone the hypercoracoid and hypocoracoid are attached. In *M. wakiyae*, the shape of this bone is different from the other species, especially in the anterior margin and dorsal part of this bone.

The hypercoracoid is a square-shaped bone, attached to the inferior wing of the clavicle. There is a round foramen at the center of the bone.

The hypocoracoid is broadly jointed at the upper margin to the hypercoracoid, and at anterior margin to the clavicle. There is a long and selender process which is arched away and touched to the lower end of the inferior wing of the clavicle.

The post-clavicle is composed of two parts. The upper part is laminar and somewhat kidney-shaped. The lower part is rather broad and laminar at the anterior part, with a ascending pointed process.

Remarks: Although Fowler (1930) and Tanaka (1931) regarded *M. wakiyae* as a synonym of *M. griseus*, and Kuroda (1947) looked upon *M. wakiyae* as a subspecies of *M. griseus*, from osteological studies we find that there are remarkable differences in the cranium, the hyoid apparatus and shoulder girdle between the two species, while *M. griseus* has a close resemblance in the above-mentioned characters to *M. elegans*. But *M. elegans* is obviously distinguishable from *M. griseus* by the comparison of the external characters as Matsubara and Yamaguchi pointed out. Accordingly, we recognize that there are three distinct species in genus *Malakichthys* and more resemblance between *M. griseus* and *M. elegans* than between *M. griseus* and *M. wakiyae* in skeletal characters.

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A New Fresh-Water Entoniscid Isopod, *Entionella okayamaensis* n. sp.

(*With 4 Text-figures*)

SUEO M. SHIINO
Faculty of Fisheries, Prefectural University of Mie

A number of specimens of an Entoniscid parasitic on *Sesarma* (*Holometopus*) *dehaani* M.-EDWARDS collected in the River Asahi, near Okayama were sent to me by Mr. K. MATUMOTO in the Biological Institute, Okayama University last summer. They included various stages of development sufficient to make a comparison with the known forms. An examination of them revealed that they are a new species blonging to the genus *Entionella* MIYASHITA and provide the second instance of the occurrence of Entoniscid in fresh or brackish water. Grateful acknowledgement is made to the named gentleman for his kindness in offering me the specimens and necessary data.

Entionella okayamaensis n. sp.

Locality: The Asahi River (near Okayama), at the point 8 km up the estuary, which is the upper limit of the reach of sea-water at high tide.

Host: Sesarma (*Holometopus*) *dehaani* M.-EDWARDS. According to personal correspondence from MATUMOTO, about 1/5 of the crabs collected were parasitized. The small area, where the present parasite was discovered was also abundant in the infection of *Entionella fluviatilis* MIYASHITA on *Eriocheir japonicus* DE HAAN. But, both of the parasites were very rare outside this area. *Sesarma* (*Holometopus*) *haematocheir* (DE HAAN) and *S.* (*Sesarma*) *intermedia* (DE HAAN) also common in that river were quite immune to any of the Entoniscids.

Specimens: 6 hosts and 12 adult females with 3 younger ones. A crab contained in it 2 females and a vermiform young accompanying Cryptoniscium. Another had 2 females as well as a V-shaped young. Other 4 had 1 adult each. Rest of the parasites were sent to me extracted from the hosts.

Female (Figs. 1 & 2, A–C): Bent dorsally at the junction of thorax and abdomen, showing the characters of *Entione*-group. From hood to posterior end of thorax 18 mm, abdomen 9 mm in a moderately large specimen. Marsupium full of ova whitish to grayish white in alcohol, ovary yellowish white, and abdomen whitish.

Marsupium with many folds and constrictions; hood rather large hanging over cephalogaster. The latter bilobed, bearing ordinarily-organized antennae.



Fig. 1. *Entionella okayamaensis* n. sp., female. A, female and male enclosed in host membrane ; B, female with membrane removed ; C, cephalon and pereiomeres, dorsal view ; D, abdomen, lateral view ; E, same, ventral view (with lateral plates removed). lp 1–2, 1st and 2nd lateral plates ; mp 1–5, 1st to 5th oostegites ; mxp, maxilliped ; pl 1–5, 1st to 5th pleopoda ; pr 2 & 6, 2nd and 6th pereiopoda. A ×3.7 ; B ×4.9 ; C-E ×7.3.

Maxillipeds composed of a broad, more or less frilled exopodite, a much smaller, crescentic endopodite and an oval coxopodite on either side. Thorax cylindrical, without any ovarian process, but with a series of small, paired lateral protuberances along dorso-lateral border in aged specimens. 1st pair of oostegites inserted just behind the maxillipeds, complicately folded and crumpled. Ascendant lamella curved over cephalogaster, folded longitudinally, deeply lobed on margin so as to form many secondary pockets, transverse one unusually large resembling ascendant one in appearance, recurrent one elongate, with rugged surface. 2nd pair of oostegites small, remaining to cover merely a basal portion of 1st pair. Other 3 pairs also small, only slightly overlapping one another, and the fellows of both sides not meeting along the mid-line. 1st pair of pereiopoda absent, 2nd close to the bases of maxillipeds, and succeeding 3 at anterior end of insertion line of corresponding oostegites. They are represented each by a tubercle and a dactyliform process. Last 2 pairs of pereiopoda present at posterior end of thorax as crescentic lobes adjoining together on either side. Abdomen slender, a little longer than thorax. Pleural lamellae of first 2 segments strongly folded and crispate, exhibiting a bouquet-like appearance. They have each a thin, tubular peduncle, which is very long in 1st pair, but very short in 2nd. Lamellae much reduced or almost obsolete in other segments, and simply lamellar, if present. Pleopoda lamellar, with members of both sides overlapping only slightly or not along mid-line. Pygidum bifid.

Male (Fig. 2, C–I): Found within narrow space between dorsal face of female and host membrane. Body showing a ventral curvature, 3.5 mm long in extended condition, 0.83 mm wide in 5th pereiomere. Whitish in alcohol, with a pair of very minute pigment spots on dorsal face near posterior border of 1st pereiomere.

Cephalon fused with next somite, demarcation being indicated by a shallow, transverse, surface groove as well as by lateral notches. Antennules are large bosses as usual, maxillae oblong lamellae, antennae and maxillipeds missing. Thorax tapers from widest 5th somite towards 1st which is 1/3 as wide as 5th; 6th subequal to 5th, but 7th narrower. Lateral plates projecting nearly horizontally in round lobes. Pereiopoda in first 6 somites, 5-jointed. 1st and 4th joints elongate, interposing between them much shorter 2nd and 3rd. 4th thickly covered by minute cirri in distal portion and tipped by unguiform rudimentary 5th; 3rd also with a few cirri. Abdomen has 6 somites cylindrical except 1st which is produced laterally in narrow lobes, pointed at their ends. Last somite bifurcates into short conical processes. Each of first 4 somites bears a medio-ventral hook, which is well curved in 1st somite, but rudimentary in 3rd and 4th.

Young females (Fig. 3, H): Two stages of "forme asticot" were found.



Fig. 2. *Entionella okayamaensis* n. sp. A-C, female; D-I, male. A, 1st oostegite; B, maxilliped and 2nd oostegite; C, 2nd pereiopod; D, male, lateral view; E, anterior region of body (up to 5th pereiomere); F, posterior region (from 6th pereiomere backward); G, cephalon, ventral view; H, 5th pereiopod; I, pleotelson, ventro-lateral view. al, ascendant lamella; mp 2, 2nd oostegite; mxp, maxilliped; pr 2, 2nd pereiopod; rl, recurrent lamella; tl, transverse lamella. A ×7,3; B ×10; C ×13,3; D-F ×41; G ×83; H, I ×170.

One was more or less straightened, while the other showed a V-shaped dorsal curvature. Pleural lamellae are crispate and notched on margin, but not folded as in the adult. Marsupium not yet developed. They accompanied each a young male, the Cryptoniscium.

Cryptoniscium (Fig. 3, A–G): Body fusiform, strongly convex dorsally, 0.48 mm long, 0.18 mm wide at 4th pereiomere. A pair of eye pigments besides irregularly scattered patches over dorsal face. Cephalon semicircular, round in front. Antenules biramous. 1st joint of peduncle short but produced backwards in an angular lobe, 2nd conical, and both hairy on distal border. Endopodite

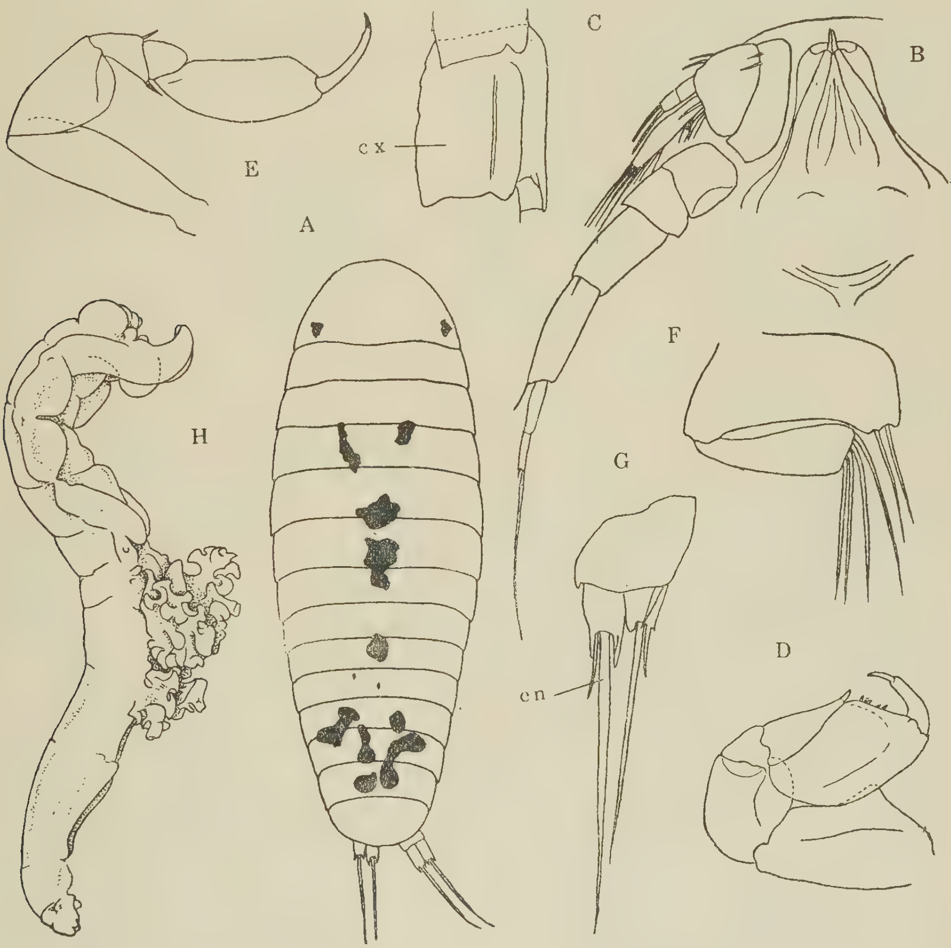


Fig. 3. *Entionella okayamaensis* n. sp. A-G, Cryptoniscium ; A, dorsal view ; B, cephalon, ventral view ; C, coxal plate of pereiomere ; D, 6th pereiopod ; E, 7th pereiopod ; F, 1st pleopod ; G, uropod ; H, a younger form. cx, coxal plate ; en, endopodite. A ×162 ; B-G ×490 ; H ×10.

filiform, non-articulated, as long as peduncle and twice longer than bi-articulated exopodite, both rami ending in stiff setae. Antennae extending as far back as 5th pereiomere, 6-jointed. 4 peduncular joints comparatively thick, basal 2 of these being much shorter than others. Flagellum bi-articulated, much thinner and shorter than 4th joint of peduncle and with a long apical hair. Thoracic

somites transversely linear, 4th of them widest. Coxal plates oblong, angular at post-lateral angle, and entire around their free margins. First 6 pairs of pereiopoda resembling one another, with all podomeres distinct. Dactylus prehensile, ending in a sharp claw, propodus inflated, with a few spinules on distal border, carpus attached along inner side of propodus, acuminating to the tip which bears a short spine, merus small, ischium expanded outwards in a round lobe, and basis produced triangularly. Last pair of pereiopoda longer than foregoing ones and different in structure. Propodus slender, not forming a subchela with dactylus, carpus small, triangular, articulating with proximal end of propodus, merus with a spine respectively at outer- and inner-distal angles, ischium with a round expansion, but basis simple and slender. Abdomen tapering backwards, inconsciously continued from thorax having somites similar in appearance except the last which is round on posterior margin. 5 pairs of pereiopoda uniform in structure. Protopodite prolonged internally in an oblong plate, issuing 2 setae at outer distal angle instead of endopodite, exopodite a narrow elongate plate, tipped by 4 setae. Uropoda biramous. Protopodite thick and short, with an outer distal spine, endopodite a little longer than exopodite, both being shorter than protopodite, and bearing each a long terminal spine besides short ones.

Epicaridium (Fig. 4): Strongly convex dorsally, elongate ovoidal in outline, 0.22 mm long, 0.12 mm wide at 3rd pereiomere. Rather thickly pigmented on dorsal face of thorax, besides with a pair of ocular patches. Cephalon widely round in front. Antennules short, bi-articulated and tipped by a few setae. Antennae extending a little beyond posterior end of thorax, composed of 4-jointed thicker peduncle and far thinner 2-jointed flagellum which is a little longer than last joint of peduncle, and ends in a long and a short hairs. Maxillae and Maxillipeds undefined. Thorax consists of 7 transversely linear segments; 7th not yet developing limbs. First 5 pereiopoda resembling one another, prehensile. Pro-carpus dilated in an oval palm salient on inner border and with 2 minute setae, merus small, triangular, and other joints elongate. Last pair of pereiopoda more slender and longer than preceding pairs. Pro-carpus forms a round fist and has a minute spinule-like dactylus which stands at the apex and nearer to one side. Merus much longer than in other limbs. Abdomen 6-segmented, tapering backwards. First 5 segments resembling thoracic ones, while the last with a slight median process on posterior margin. Pleopoda uniramous. Protopodite narrow, acuminating to a point distally and ending in a single hair, exopodite with truncate apex and with 3 hairs. Uropoda biramous; peduncle short, with a single spine at inner distal angle; both rami subequal in length, bearing each a long terminal spine put between much shorter 2.

Remarks: In lacking dorsal or ventral ovarian process in the female thorax and in having bouquet-like pleural lamellae only in the first 2 segments

of abdomen, there may be no doubt in that the new species is congeneric with *Entionella fluviatilis*. The two, however, may be distinguished from each other by the following characteristics tabulated below:

		fluviatilis	*okayamaensis*
Female	1st oostegite	folded	complicately folded
	1st pleural lamella	without stalk	with elongate stalk
	3rd–5th pleural lamellae	distinct	indistinct
Male	pleo-telson	deeply bifid	shallowly bifid
	7th pereiomere	without expansion	with lateral expansions
Epicaridium	carpus of 6th pereiopod	elongate oval, lacking dactylus	round, with a spini-form datylus

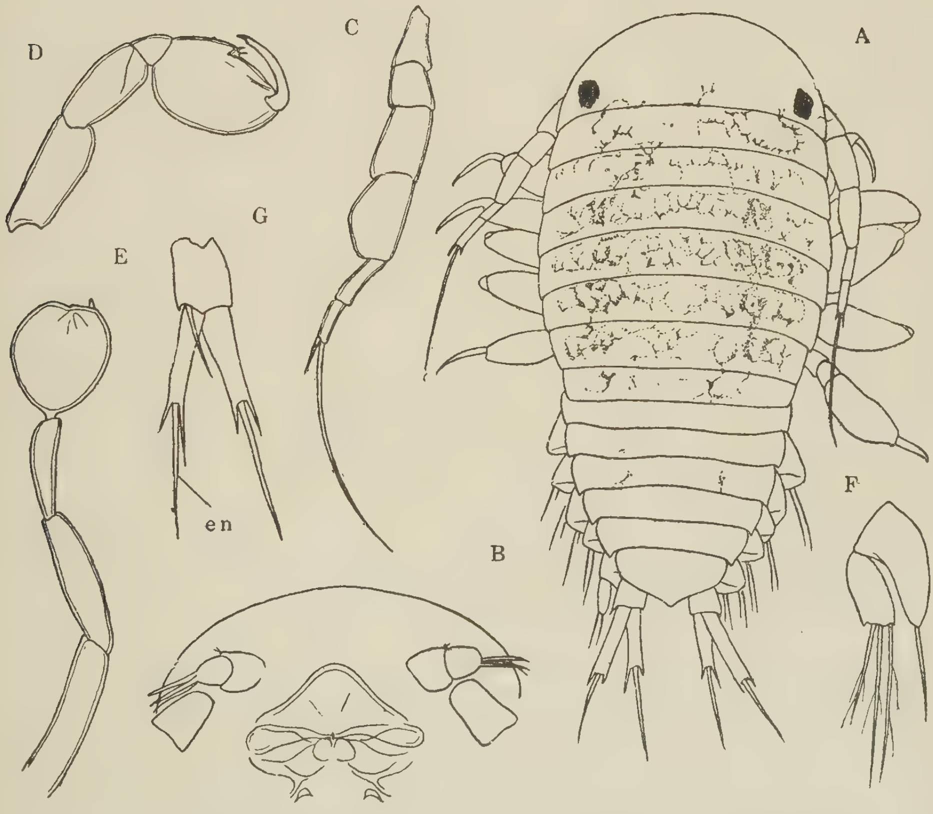


Fig. 4. *Entionella okayamaensis* n. sp., Epicaridium. A, dorsal view; B, cephalon, ventral view; C, 2nd antenna; D, 5th pereiopod; E, 6th pereiopod F, 5th pleopod; G, uropod, ventral view. en, endopodite. A ×340; B-G ×490.

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Copepods Parasitic on Japanese Fishes

2. On Two New Species of the Family Trebidae

(*With 4 Text-figures*)

SUEO M. SHIINO

Faculty of Fisheries, Prefectural University of Mie

The Trebidae is a small family containing a single genus, *Trebius*. It bears a close resemblance to the Caligidae in the general constitution of the body. The chief and fundamental differences lying between them are that the 3rd thoracic segment, which is united with the carapace in the Caligidae, is distinct in the Trebidae and that the 1st and the last swimming legs uniramous in the former are biramous in the latter.

In so far as I am aware, no representative of this family has been recorded from the waters around our country. Two new species showing the characteristics of this family and belonging to the genus *Trebius* have recently come in my hand, one from an angel shark and the other from a sting ray. They will be described here.

Family TREBIDAE

Genus *Trebius* Krφyer, 1838

Trebius longicaudatus n. sp.

(Figs. 1 & 2)

Occurrence: Found by myself within the buccal cavity, around the mouth, or on the ventral surface of the body of *Squatina nebulosa* Regan caught off Tyôsi, Tiba Prefecture. 15 females, no male.

Female: Color in alcohol yellowish, without pigment spots. Measurements of the holotype in mm: Body length 11.93, carapace 2.72×3.43, 3rd thoracic segment 0.50×1.36, 4th thoracic segment 0.79×1.00, genital segment 2.78×1.93, 1st abdominal segment 2.14×0.68, 2nd abdominal segment 3.00×0.67, length of egg strings 5.50.

Carapace orbicular, wider than long, 2/9 the entire body length, moderately convex dorsally. Frontal plates narrow, half as wide as carapace. Anterior margin flatly round with a slight median incision at the centre and a narrow chitinous rim. Lateral borders widely round, but sinuous in the middle portion and with rather wide chitinous rim. Lateral lobes short, narrow; posterior sinuses oval and small. Eyes indistinct. Dorsal longitudinal grooves with anterior

halves concave towards the median axis, posterior halves divergent backwards though curving inwards near the ends; transverse suture straight, somewhat indistinct on the median. Line of articulation between thoracic area of carapace and 3rd thoracic segment also straight. The latter shorter than the former, 1/5 as long as carapace, and a little less than half as wide. It extends beyond lateral lobes, and has more or less trapezoid posterior border.

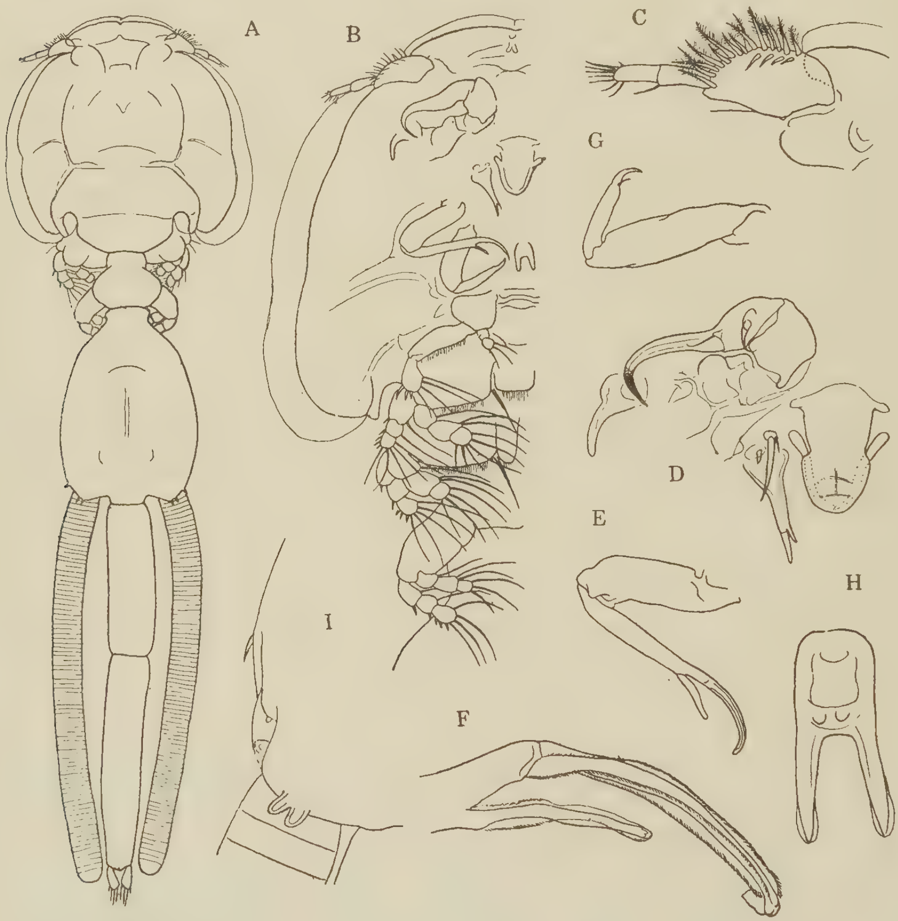


Fig. 1. *Trebius longicaudatus* n. sp., female. A, female, dorsal view; B, same, right half of carapace and thoracic segments, ventral view; C, 1st antenna, ventral view; D, 2nd antenna, maxillae and oral tube; E, 1st maxilliped; F, tip of same, further enlarged; G, 2nd maxilliped; H, sternal furca; I, postero-lateral angle of genital segment, dorsal view. A ×9.3; B ×18; C-E, G ×37; F ×123; H ×83; I ×41.

Fourth thoracic segment about 2/3 the width of 3rd, a little wider than long. It has round sides and is contracted anteriorly into a short neck where it joins the preceding segment. Genital segment large, only slightly shorter than carapace, and one and half times as long as its own width. The segment is

flask-shaped, having gracefully round sides, which converge gradually anteriorly so as to be connected with the preceding segment by a short neck. It possesses 3 dactyliform papillae at each post-lateral angle on dorsal surface and a spine a little in front. Posterior border is slightly concave, but produced on the median into a very short lobe, to which the abdomen is contiguous. The latter is elongated, cylindrical, nearly twice as long as genital segment, 2-segmented; posterior segment is a quarter longer than the anterior. Egg-strings somewhat narrower than abdomen and a little or not longer.

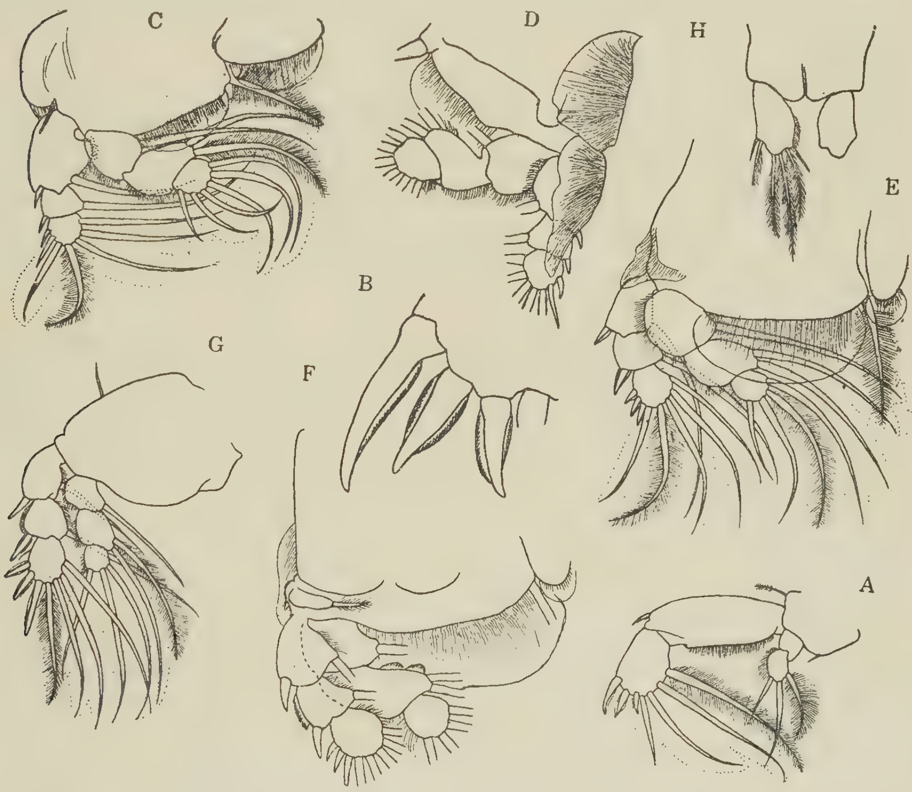


Fig. 2. *Trebius longicaudatus* n. sp., female. A, 1st leg; B, tip of exopodite of same, further enlarged; C, 2nd leg; D, same, posterior surface; E, 3rd leg; F, same, posterior surface; G, 4th leg; H, caudal rami. A, C, E, G, H ×37; B ×170; D, F ×41.

First antennae with 2-jointed flagellum; distal joint bearing a number of apical setae, while proximal joint only one. Peduncle has rows of plumose spines along anterior border. Terminal claw of 2nd antennae slender, long, well curved, ending in a sharply pointed tip, and with a curved spine close to its base besides with a minute seta somewhat more distally. First maxillae dactyliform, only slightly curved, with blunt apices and enlarged bases. Each of 2nd

maxillae a narrow elongate lobe, bipartite at the tip into longer outer and shorter inner branches, and with 2 papillae at the enlarged base, one carrying a short spine, and the other a far stronger spine besides a minute one. Oral tube broad, round at the summit. First maxillipeds small, composed of 2 joints of subequal length; apical spines different in size, rather thick, blunt at their tips and with finely serrated rims. Second maxillipeds rather feeble, having linear, slender palm; terminal claw extending a little beyond the centre of palm, nearly straight, curving only at the end, and carrying a spine on inner margin at the base of curved part. Sternal fork has a quadrangular base and nearly parallel arms, tips of which are rimmed by narrow crescent membrane both internally and externally.

All 4 pairs of swimming legs have 2 rami composed of 3 joints except 1st pair in which these are 2-jointed. Endopodite of the named pair much smaller than exopodite. Second and 3rd pairs possess very broad protopodite, this of either side being connected by sternal plate. Protopodite of 4th pair narrower than in foregoing ones and lacks sternal plate. 5th legs absent. Arrangement of spines in each pair will be shown in the table:*

Legs	Margins	Sternal plate	Protopodite	Exopodite			Endopodite		
				1st joint	2nd joint	3rd joint	1st joint	2nd joint	3rd joint
I	outer inner		1p 1s	1h c	3H 4P			c 3P	
II	outer inner	f	f, 1h 1P, f	f, 1H c, 1P	1H 1P	2H 5P	c 1P	c c, 2P	c 6P
III	outer inner	f	1p, f 1P, f	1H c, 1P	C, 1H c, 1P	3H 5P	c 1P	c 2C, 2P	c 4P
IV	outer inner		1s c, 1P	1H c, 1P	C, 1H 4P	1s, 3H 4P	c 1P	c 2P	c, 1rh 3P

All of the simple spines present on the legs have finely serrated rims. In 2nd legs, protopodite as well as 1st joint of exopodite provided with very broad striated membrane on outer border. Protopodite of 3rd legs also with the membrane on outer margin, and a short plumose spine surmounting on a transverse ridge which is directed inwards at outer distal angle on posterior surface. Second exopod joint of last 2 pairs of legs have finely serrated narrow rim along outer margin, and 2nd endopod joint of 3rd pair bears 2 of such rims on inner border.

* Abbreviations used in the tables:
C, row of cirri; c, row of cilia; f, membraneous flange; H, longer spine; h, shorter spine; P, longer plumose spine; p, shorter plumose spine; rh, rudimentary spine; s, single seta.

Caudal rami very small, more or less triangular, thickly ciliated along inner margin, with 4 plumose spines at the end and 2 shorter simple ones, arranged one on each side of them.

Male unrepresented in the collection.

Remarks: The new species is characterized, above all things, by its very long abdomen. Based on the measurements taken from the figures given by authors, I have estimated the ratio of the length of the abdomen to that of the carapace (excluding the 3rd thoracic segment) in each of the known species. The results are indicated in the following table, in which the number of segments composing this part of the body is also shown for each species.

	caudatus	*tenui-furcatus*	*bilobatus*	*lati-furcatus*	*exilis*	*longi-caudatus*
Abdominal length / Carapace length	1.15	1.15 or 0.76	1.21	0.88	0.50	1.90
Number of abdominal segments	3	2	3	3	1	2

The present species is different from the known ones also in a number of other points. In general appearance it bears a certain resemblance to KRØYER's *caudatus*. Not to speak of the abdomen, however, that the two are distinct is apparent from the following considerations: In KRØYER's species, the 3rd joint of the exopodite of the 2nd legs has 2 simple external spines besides plumose ones; here the external spine is only one. A single spine of the similar nature found on the 3rd joint of the endopodite in the 3rd legs of *caudatus* is absent from that of the present species. Marginal spines at the posterior extremity of the genital segment are long and pointed in *caudatus*, while they are shorter and blunt in *longicaudatus*. Further, the 4 apical spines on the caudal rami of the former are interposed between 2 far shorter simple spines in the latter.

Although the present species is in accord with *tenuifurcatus* RATHBUN in having 2-segmented abdomen, the differences are found in the structure of the 2nd antennae, in the outline of the genital segment and in that the marginal spines at the posterior extremity of this segment are rudimentary in the former. The new species is distinguished also from *latifurcatus* WILSON by the characters of the 2nd antennae, of the sternal furca, and of the caudal rami, besides by that the abdomen is not covered by spinules as in the latter. It is discriminated finally from *exilis* WILSON by the configuration of the genital segment.

Trebius akajeii n. sp.*
(Figs. 3 & 4)

Occurrence: Collected by myself from the dorsal body surface of *Dysyatis akajeii* (Müller & Heule) caught off Owase, Mie Prefecture. 21 females, of which 7 are in more or less young stages; no male.

Female (Figs. 3, A, E–N & 4): Color yellowish, with pigment patterns on dorsal face and on protopodite of swimming legs. Eyes red in color. Body sparsely covered by very tiny spinules, especially in posterior region. Measurements of the holotype in mm: Body length 5.67, carapace 1.67×2.09, 3rd thoracic segment 0.33×0.91, 4th thoracic segment 0.48×0.71, genital segment 1.52×1.19, total length of abdomen 1.67, 1st abdominal segment 0.86×0.40, 2nd abdominal segment 0.52×0.33, 3rd abdominal segment 0.29×0.24, length of egg cases 2.61.

Carapace resembling that of *longicaudatus*, suborbicular, wider than long, about 3/10 as long as body, convex dorsally. Frontal plates half as wide as carapace. Anterior border very slightly arched, with narrow rim, but lacking the median notch. Lateral margins widely round or slightly sinuous in the central portion according to the circumstances, and with 2 long, stiff setae on either side in addition to ordinary broad membraneous rim. Lateral lobes broad, but appearing narrower on account of being usually crooked more or less ventrally. Eyes distinct, placed a little in front of the centre of cephalic area. Longitudinal grooves parallel with the median axis in their anterior halves, but divergent in posterior halves, and connected with each other by the nearly straight transverse suture. Posterior sinuses small and oval. Third thoracic segment 1/5 as long as and slightly less than half as wide as carapace, from which it is bordered by a straight articulation line. Posterior margin forms a trapezium and passes to either lateral side through an angular corner.

Fourth thoracic segment with width 2/3 that of 3rd and one and half times its own length; 2 sides convex, being widest and angular between the bases of legs. The segment contracts anteriorly into a short neck to join the foregoing segment. Genital segment large, about 4/5 as wide as long, a little shorter than carapace and flask-shaped. But, differing from the same segment of *longicaudatus*, it has parallel sides which converge anteriorly to form a somewhat elongate neck where it joins 4th segment. The 2 sides abruptly curving pass to somewhat convex posterior margin. The segment is provided at each postero-lateral corner with a thin crescent dorsal lobe which issues 2 or 3 sharp, spine-like processess over egg case. It bears, further, a similar process on

* *Akajei* is the Jananese name of the host.



Fig. 3. *Trebius akajeii* n. sp., female. A-D, dorsal view; A, adult female; B, another female with shorter abdomen and egg strings; C, posterior part of body of a younger female; D, a further younger female; E-N, appendages of the female shown in A; E, 1st antenna, ventral view; F, 2nd antenna, maxillae and oral tube; G, tip of mandible; H, 1st maxilliped; I, tip of same, further enlarged; J, 2nd maxilliped; K, sternal furca; L, posterior end of genital segment, dorsal view; M, same, ventral view; N, caudal ramus; O, postero-lateral angle of genital segment of the female C; P, same of the female D. A-D ×14; E, F, H, J, N-P ×83; G ×487; I ×170; K ×120; L, M ×41.

ventral surface just inside the base of each egg case, and a low papilla surmounted by 3 short plumose spines at each lateral corner which represent the rudiment of 5th leg. Abdomen elongate, as long as carapace, cylindrical, and composed of 3 segments. First segment is longer and slightly wider than 2nd, which is yet larger than 3rd both in length and width, and indistinctly bordered from each other. Egg strings extending much beyond abdomen.

Flagellum of 1st antennae 1-jointed, about as long as basal joint, bearing apical setae and sensory filaments besides with a seta at about the centre of its length. Basal joint thickly covered by longer and shorter plumose spines along anterior border and with papillae at distal end. Terminal claw of 2nd antennae elongated so as to form a well-curved, sharp hook and swollen at the base into a prominent bulge; it bears a curved spine near the base and a short seta more distally. Second joint short; basal joint with a broad, short spine on posterior border. A similar spine present also on the sternum a short distance apart from each antennal base outwards. First maxillae hook-like, more or less pointed at the tips and with swollen, round bases. Each of 2nd maxillae with broad base, but elongated distally into a narrow lobe which is bifid at the tip into longer outer and shorter inner branches. Maxillary base has 2 papillae, one carrying a strong spine associated with a much shorter one, and the other a minute rudimentary spine. Mouth tube round at the end and with a pair of short, broad spines, one on each side of its broad base. Mandibles with apical parts curved and finely serrated along inner borders. First maxillipeds small, distal joint comparatively thick; longer member of apical spines blunt and curved like a hook at the tip and with 4 finely serrated rims along its entire length, while shorter member sharply pointed and with 2 rims. Second maxillipeds feeble, basal joint narrow, linear, having same width throughout its whole length; apical joint about 3/4 as long as the basal, also linear, somewhat narrowed and curved at the tip, and with an accessory spine. Sternal furca has a round base showing an oval foramen and issuing 2 divergent arms which are blunt at the apices and bear very narrow rims.

Endopodite of 1st pair of swimming legs relatively smaller than in *longicaudatus*. Both rami of this pair 2-jointed, while those of others 3-jointed. Protopodite of 2nd and 3rd pairs expanded, that of either side connected by sternal plate. In other pairs, member of both sides apart, being united by a transverse bar. Fifth legs present as stated above. Arrangement and number of spines on each pair of legs will be apparent from the table inserted at the top of the next page.

Simple spines on the legs have finely serrated rims along one or two borders. But, short spine on 1st exopod joint of 1st legs not serrated; external spine on 3rd endopod joint of last 2 legs also without rims and indistinctly

Legs	Margins	Sternal plate	Protopodite	Exopodite 1st joint	Exopodite 2nd joint	Exopodite 3rd joint	Endopodite 1st joint	Endopodite 2nd joint	Endopodite 3rd joint
I	outer inner		1p 1p	1h 1s, c	3H c, 4P			c 3P	
II	outer inner	f	f, 1p 1P, f	f, 1H c, 1P	f, 1H c, 1P	f, 2H c, 5P	c 1P	c 2P	c 6P
III	outer inner	f	f, 1p 1P, f	1H c, 1P	C, 1H c, 1P	C, 3H c, 5P	c 1P	c c, 2P	c, 1h c, 4P
IV	outer inner		1p C	1H c, 1P	C, 1H c, 1P	C, 3H c, 4P	c 1P	c c, 2P	c, 1h c, 3P

separated from the segment at the base. External spine on each joint of endopodite of 2nd legs surrounded at the base with a striated membrane, which is similar in structure to the membraneous rim along 1st joint and protopodite, but much smaller. Distal one of the 2 external spines present on terminal joint of this ramus is fringed by fine setae along inner border, while by a narrow membraneous rim along the other. Protopodite of penultimate limb pair has a short, plumose seta which arises from an elongate papilla present close to the base of exopodite on ventral surface. Protopodite of last pair ornamented with a serrated rim on inner border.

Each of caudal rami a small narrow lobe, twice as long as wide and carrying 4 plumose terminal spines; outermost of these spines is somewhat apart from others at the base and much shorter. Besides, a further shorter spine is placed on each side of them. Inner borders of the rami thickly ciliated, outer borders as well as surfaces with fine sparse spinules.

Present collection includes other 3 types of females. Though they do not show any differences in the character of the anterior part of the body and in the details of the appendages, they disagree with the holotype in the relative length of the abdomen and in the constitution of the genital segment. It appears that the disagreements depend upon the differences in developmental stages, as a series of gradual changes according to the growth of body can be observed.

The female shown in Fig. 3, B is a representative of the stage which is somewhat younger though fully mature. It has the carapace similar in size to that of the holotype, and is also in agreement in the characters of the free thoracic and genital segments. But, the abdomen and the egg cases are much shorter, the former being 4/5 as long as the carapace and extending beyond the latter. Measurements of the body and its parts are: Entire length 5.10 mm, carapace 1.67×2.00, genital segment 1.24×1.05, length of abdomen 1.34, length of egg strings 1.38.

Another type of the female shown in Fig. 3, C is also an almost exact



Fig. 4. *Trebius akajeii* n. sp., female. Thoracic appendages of the female shown in Fig. 3, A. A, 1st leg of left; B, a spine of same, further enlarged; C, 2nd leg of right; D, same, outer border of 3rd segment of exopodite, further enlarged; E, 2nd leg of left, exopodite, posterior view; F, 3rd leg of right; G, same leg of left, outer-distal angle of protopodite, posterior view; H, 4th leg of left. A, C, E-H ×83; B, D ×170.

counterpart of the holotype in the constitution of the anterior segments, but differs in that of posterior segments. It does not carry egg cases, but has many ova within the gonoduct. The body is 4.48 mm long in one of the specimens. Genital segment, being proportionally smaller than in the adult, has the length 3/5 that of the carapace, and is somewhat more angular at the antero-lateral corners. The posterior spines are more or less crumpled and the rudiments of the 5th legs are associated on either side with an accessory spine present a little forwards. Abdomen is as long as the genital segment.

The youngest stage collected is shown in Fig. 3, D. It measures 3.34 mm in length. The 4th thoracic segment is different in shape from that of the adult, showing a lunular outline. Genital segment, which has the length equal to the abdomen, is further shorter than in the above named stage and is about half as long as the carapace. It is also relatively narrower and lacks the posterior spines entirely. This individual appears as if to represent a male, but shows a distinct female organs within the genital segment.

Remarks: In general appearance of the body as well as in having the 3-segmented abdomen, the present species seems to be close to *caudatus* Krøyer and *latifurcatus* Wilson. It also bears a certain resemblance to *tenuifurcatus* Rathbun which has the abdomen composed of 2 segments. Especially, the female shown in Fig. 3, B is substantially in accord with this species figured by Wilson in 1908 in the proportion of the segments and in the shortness of the egg cases. Differences from those known species will be apparent from the following comparison:

	latifurcatus	*caudatus*	*tenuifurcatus*	*akajeii*
Number of simple and plumose spines on 2nd exopod joint of 1st leg.	2 & 4	3 & 4	4 & 3	3 & 4
Number of plumose spines on 3rd endopod joint of 2nd leg.	5	6	6	6
Number of simple spines on 3rd exopod joint of 2nd leg.	3	1	1	2
Number of plumose spines on 3rd endopod joint of 3rd leg.	5	4	4	4

Besides in the thoracic limbs, there are also some disagreement in other appendages. The 2nd antennae, the 1st maxillae and the sternal fork of the new species are different from those of *caudatus*. The first named appendages are alike between the new species and *latifurcatus*, but the others differ entirely. The first maxillae resemble those of *exilis* and *tenuifurcatus*, and the sternal fork is rather closer to the same structure of the latter. As pointed above,

tenuifurcatus described by Wilson in 1908 and 1932 resembles the present species shown in Fig. 3, B. But, this species recorded by the same author in 1907 does not show any close resemblance to any of the present females, and moreover disagree even with his other figures given later, in the outline of the genital segment and the abdomen. Although his earlier figure appears to have been based on somewhat poorly preserved specimen, it is doubtful to me if this and other *tenuifurcatus* of him really belong to one and the same species.

The short, 1-segmented abdomen of *exilis* Wilson will give us a clear information about the distinction between this and the new species. In having the 3-segmented abdomen, the latter is in accord with *bilobatus* Brian, but is different in being destitute of posteriorly elongated lobes on the genital segment.

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Copepods Parasitic on Japanese Fishes

3. On Two New Species of the Genus *Anuretes*

(*With 5 Text-figures*)

SUEO M. SHIINO
Faculty of Fisheries, Prefectural University of Mie

Anuretes HELLER, containing a few species, is a small genus of the family Caligidae. It is in agreement with *Lepeophtheirus* in the general constitution of the body, but different in that the abdomen is completely absorbed by the genital segment, the caudal rami being attached directly to the latter. In Japan, the genus has been represented by 2 species, *plectorhynchi* YAMAGUTI and *renalis* HEEGAARD. I have recently obtained 2 species, one from the body surface of *Xesurus scalprum* and the other from *Zonopsis nebulosa*. Both of the parasites are new to science and although they have small but distinct abdomen, it appears to me appropriate, for the present, to place them in *Anuretes* for the reason discussed later.

Genus *Anuretes* HELLER, 1865

Anuretes serratus n. sp.

(Figs. 1 & 2)

Occurrence: Found on the body surface of the littoral fish, *Xesurus scalprum* (CUVIER & VALENCIENNES) taken by myself at Seto, Wakayama Prefecture. 3 females, no male.

Female: Color in alcohol yellowish, sparsely spotted with dendritic pigment on dorsal face. Measurements in mm: Body length 2.31, carapace 1.77×1.61, width of posterior lobe 0.74, 4th thoracic segment 0.06×0.48, genital segment (including abdomen) 0.48×0.74, abdomen 0.13×0.23.

Carapace elliptic, longer than wide, flattened dorso-ventrally. Frontal plates half as wide as carapace, not prominent; anterior border widely round, but notched on the median, and with narrow membraneous rim. No adhesive lunule. Lateral areas less than half the width of central area; free margins entire, gracefully round and furnished with a number of setae in addition to ordinary broad membraneous rims. Longitudinal grooves substantially parallel with each other being only slightly undulated; transverse groove indistinct. Median lobe as broad as frontal plates, but a little narrower anteriorly; posterior border on the same level as the tips of lateral lobes, nearly straight, and somewhat produced laterally.

Posterior sinuses parallel with median axis deep and oval, having much narrowed openings. Eyes distinct, placed a quarter of the length of carapace behind its anterior border.



Fig. 1. *Anuretes serratus* n. sp., female. A, female, dorsal view; B, same, ventral view; C, 1st antenna, dorsal view; D, same, ventral view; E, 2nd antenna and maxillae; F, 1st maxilliped; G, tip of same; H, 2nd maxilliped; I, tip of same, extended; J, terminal region of body, ventral view. A ×21, B ×32, C-E, G-I ×120, F, J ×59.

Fourth thoracic segment very short, transversely linear, scarcely 1/3 the width of carapace, beneath which it is partly concealed. Genital segment semicircular in outline, equal to median lobe of carapace in width, and a little more than twice as wide as its own length. Anterior and lateral borders form a continuous arc terminating in angular postero-lateral corner on either side; posterior border more or less straight excluding the abdomen present at the

centre. Abdomen much reduced in size, about 1/3 as long as genital segment with which it is completely coalesced; 2 sides converging backwards, hind margin truncate.

Joints of 1st antennae subequal to each other in length; distal joint bearing a tuft of apical setae and a solitary one about the middle of its length, proximal joint with marginal rows of plumose spines, besides a few scattered ones on dorsal face. Terminal joint of 2nd antennae curved at the tip, but neither so sharp nor slender as in ordinary case, with 2 spinules, one close to the base and the other at the centre; succeeding joint as long as the terminal, uniform in width throughout entire length, basal joint short, provided with a broad, spatulate process on posterior side. Each of 1st maxillae very small, divided by a notch on inner margin into round base and short lobe which is somewhat curved outwards and pointed. It accompanies on inner side of the base 3 papillae, each carrying a few setae. Second maxillae well developed, enlarged at the base, narrowed and bifurcated apically into a pointed, spine-like outer and round, broader inner lobes. Just in front of the base of each of them, there is a tubercle issuing 3 spinules. Mouth tube slender and conical. First maxillipeds long and unusually slender; distal joint longer than the proximal, with 2, rimmed, apical spines of different lengths. Second maxillipeds rather feeble, with palm not inflated and a quarter as wide as long; claw hardly reaching the centre of palm, comparatively broad, acuminated only at its blunt tip, and with an oval process on posterior side at the base and a spinule on anterior side. Sternal furca absent.

First and 4th pairs of thoracic legs uniramous, others biramous. But, rudiment of endopodite is present on anterior face of protopodite in 1st legs as a short transparent lobe tipped by 3 setae. Arrangement of spines on them will be clarified by the following table:*

Legs	Margins	Sternal plate	Protopodite	Exopodite 1st joint	Exopodite 2nd joint	Exopodite 3rd joint	Endopodite 1st joint	Endopodite 2nd joint
I	outer		1p		3H, 1p			
	inner		1p, 1H	c	3P			
II	outer	f		f, 1H	1H	2H	c	c, 4P
	inner		1P, 1h, f	c, 1P	1P	6P	1P	4P
III	outer	f	f, 1p	1H, 4H			c	
	inner		1P, f	6p				6P
IV	outer		1p	1H	4H			
	inner							

* Abbreviations used in the tables:
c, row of cilia; f, membraneous flange; H, longer simple spine; h, shorter simple spine; P, longer plumose spine; p, shorter plumose spine.

Of terminal spines on 3rd joint of 1st legs, the outermost composed of a narrow axis and a pair of lateral laminae having serrated margin and striated surface; the rest dilated like a hand and cut into several sharp fingers around margin. Besides these, a short plumose accessory spine is present on distal border



Fig. 2. *Anuretes serratus* n. sp., female. A, 1st leg; B, tip of same, posterior view; C, rudiment of endopod of same; D, 2nd leg; E, same, posterior side; F, 3rd leg; G, same, posterior side; H, 4th leg; I, papillae on ventral surface of genital segment. A, D-I ×120, B, C ×340.

of this joint. Terminal spine on 1st exopod joint of 2nd legs very long, curved, directed inwards and ramified on outer border into a number of short branches; that of 2nd and 3rd joints much shorter and rimmed with fine serrations. Border line between 2 distal joints of endopodite missing on anterior face. Outer ramus

of 3rd legs reduced into a single joint and with a basal hook bent inwards angularly at the centre of its length; inner ramus divisible into semicircular basal and much smaller, oval, terminal joints on posterior face, but line of articulation between them disappearing on the other face. Fourth legs slender, 3-jointed. First joint surpassing combined length of the rest 2, with a short plumose hair at the end, 2nd longer than 3rd and with a single spine; outermost of the 4 apical spines longest, a little more than thrice the lengths of others which are subequal.

Caudal rami narrow, shorter than abdomen, with 3 longer and a shorter external spines of plumose nature, besides with a simple internal one.

Remarks: It is somewhat problematical whether the new species can rightly be assigned to *Anuretes*, for the abdomen is present as in *Lepeophtheirus* though completely united with the genital segment. Apart from this question, which will be discussed later, the new species may be distinguished from all the known forms of either of the 2 genera by the characteristic apical spines on the 1st pair of swimming legs and by the branched spine on the 1st joint of exopodite of the succeeding pair. Two pairs of maxillae as well as the 2nd maxillipeds also exhibit rather unique characters for the appendages of a Caligid parasite.

Anuretes quadrilaterus n. sp.

(Figs. 3–5)

Occurrence: Found on the body surface of deep-sea fish, *Zonopsis nebulosa* (Temminck & Schlegel) purchased at the fish market at Owase, Mie Prefecture. 25 females and 4 males. Measurements of both sexes in mm:

	Body length	Carapace	Width of median lobe	4th thoracic segment	Genital segment	Abdomen	Length of eggs cases
Female	5.86	4.00×4.08	1.73	0.20×1.00	1.63×2.34	0.30×0.34	4.37
Male	3.21	2.36×2.36	0.86	0.17×0.52	0.61×0.82	0.13×0.21	

Female: Short and plump; transparent, colorless, without any pigment spots other than those of eye.

Carapace orbicular, as wide as long, having widest calibre on the level of posterior 1/3 of the length. Frontal plates half the width of carapace, without lunules; free border only slightly arched, scarcely with a median incision, and margined by a narrow rim. Lateral areas very wide, about 2/3 the width of central area, evenly round on margins, and ending in broad, well-round, posterior lobes; marginal rims relatively narrow. Longitudinal grooves only slightly divergent both in anterior and posterior arms. Transverse suture largely indistinct, remaining only laterally. Median lobe narrower than frontal plates, rather short,

and yet extending a little beyond lateral areas; posterior border somewhat concave, lateral angles round. Sinus on either side of median lobe very small. Eyes distinct, situated a little in front of the centre of cephalic area.

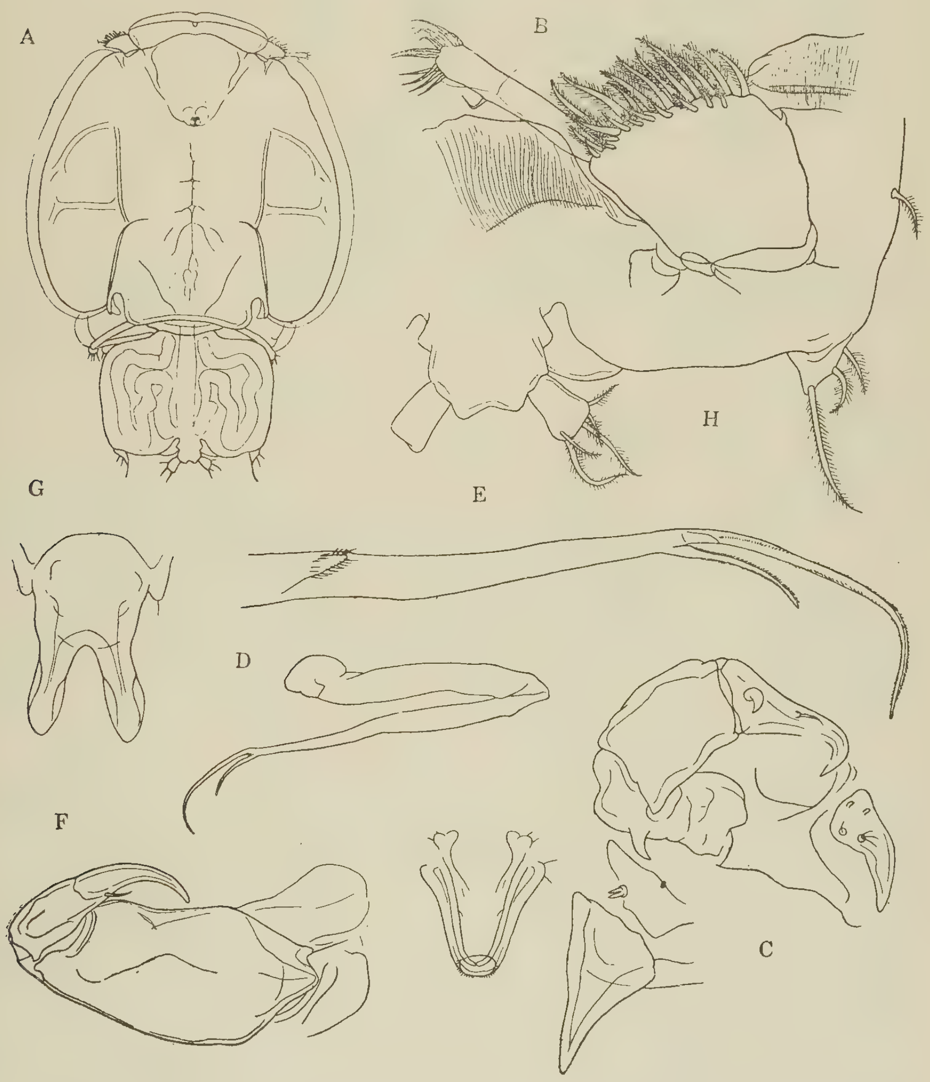


Fig. 3. *Anuretes quadrilaterus* n. sp., female. A, female, dorsal view; B, 1st antenna, ventral view; C, 2nd antenna, maxillae and oral tube; D, 1st maxilliped; E, apical joint of same, posterior view; F, 2nd maxilliped; G, sternal furca. A ×10, B, G ×83, C, H ×52, D, F ×41.

Fourth thoracic segment a quarter as wide as carapace, very short, transversely fusiform, anterior part being covered by the latter. Genital segment quadrilateral, wider than long, 2/5 as long as carapace and 4/7 as wide. Postero-



Fig. 4. *Anuretes quadrilaterus* n. sp., female. A, 1st swimming leg; B, tip of same; C, endopodite of same; D, 2nd leg; E, same, posterior face; F, 3rd leg; G, rami of same, posterior view; H, 4th leg; I, apical joint of same. A, D-F, H ×52, B ×120, C ×170. G, I ×83.

lateral angles of the segment are produced on either side into a short, small, triangular lobe which, bearing 3 plumose spines, represents 5th leg rudiment. Each of lateral borders has another spine a short distance in front of this leg. Posterior margin bears a median depression on dorsal side, within which the segment carries small, rudimentary abdomen. The latter is completely coalesced with genital segment, flattened, about as long as wide, with uneven lateral and reentrant posterior borders, and issues caudal rami postero-laterally.

Distal joint of 1st antennae slender, thickly setose at the apex and with a solitary hair a little behind; anterior border of proximal joint with dorsal row of longer plumose spines and ventral row of much shorter ones. Second antennae somewhat feeble; apical joint forms a sharp hook bearing a minute spinule about the middle of its length and a thicker one close to the base; 2nd joint about the same length, but broader, and basal joint with a short, sharp process on posterior side. First maxillae small, only slightly curved, narrowing to a blunt point; basal part with 4 small papillae, 2 of these bearing each a tuft of minute hairs. Second maxillipeds triangular, sharply pointed, and with a basal tubercle surmounted by spinules. Mouth tube conical having round apex. First maxillipeds very slender; distal joint longer than the proximal, with a triangular, setose lobe on posterior face; 2 apical spines unequal, very thin, and with fine serrations throughout their lengths. Second maxillipeds comparatively stout; terminal claw sharp, well-curved, attaining the middle of swollen basal joint, and with a short accessory spine. Two arms of sternal furca form a V and bear lunular flaps both outside and inside.

First and last pairs of swimming legs uniramous, others biramous. Arrangement of spines on them are shown in the following diagram. First legs have rudiment of endopodite on anterior face of protopodite as a small, short lobe which ends in 3 spinules and is provided with inner row of minute hairs.

Legs	Margins	Sternal plate	Protopodite	Exopodite			Endopodite		
				1st joint	2nd joint	3rd joint	1st joint	2nd joint	3rd joint
I	outer inner		1p 1H	1h c	3H, 1p 3P				
II	outer inner	f	f, 1h 1P, f	f, 1H c, 1P	1H 1P	3H 5P	c 1P	c c, 2P	c 6P
III	outer inner	f	1P, f f, 1p	1H, 3h, 1H 1P, 5P			c	c 6P	
IV	outer inner		1H, 3H 1h						

Terminal spines on 3rd joint of 1st legs with fine cirri along their borders.

They are associated with a short plumose hair. Of marginal spines on apical exopod joint of 2nd legs, 3rd from the outside is ciliated on inner border, but has a narrow, crescent rim on the other. Exopod of 3rd legs reduced into a single joint, and with sharp, only slightly curved, basal hook; endopod 2-jointed, with distal joint expanded on the outside in a semicircular lobe. Fourth legs slender, composed of only 2 joints, those of the ramus uniting into one. Second

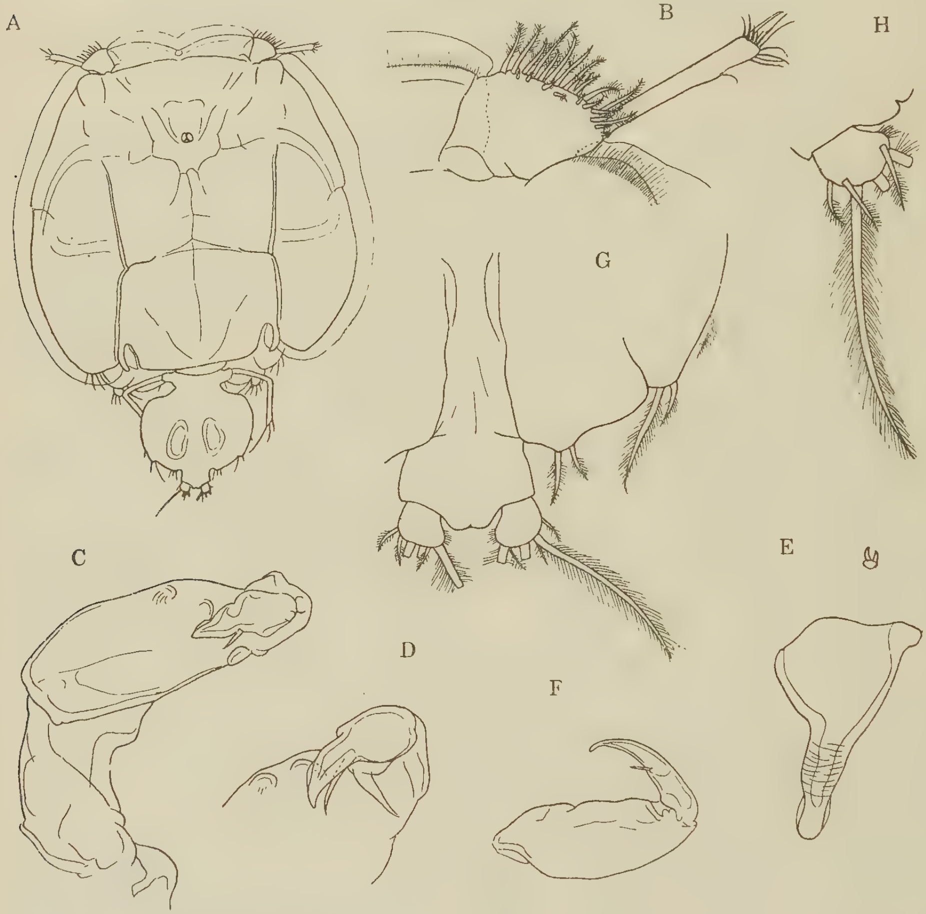


Fig. 5. *Anuretes quadrilaterus* n. sp., male. A, male, dorsal view; B, 1st antenna, ventral view; C, 2nd antenna; D, tip of same, further enlarged; E, 2nd maxilla of right side; F, 2nd maxilliped; G, posterior end of genital segment and abdomen, showing rudiments of 5th and 6th legs and caudal rami, ventral view. A ×19, B, G ×83, C, H ×120, D ×170, E, F ×41.

joint has 3 apical spines which are finely serrated on their borders and surrounded by minute cirri around their bases; innermost of them far longer than others which are subequal. This joint is provided also with a solitary spine on outer border at a point about 1/3 from the base and a minute one at inner distal angle of the tip.

Caudal rami small, slightly broader and truncated at the apices where they bear 2 longer and 3 shorter hairs of plumose nature.

Male: Smaller than female, without coloring.

Fourth thoracic segment relatively narrower than in female, transversely linear, having blunt lateral ends and 2/9 as wide as carapace which is an exact counterpart of that of the female. Genital segment a quarter as long as carapace, 3/4 as long as its own width, wider anteriorly than posteriorly, and united with foregoing segment by a very short neck. It has 2 pairs of small lobes on its well-round sides, a pair on either side of the abdominal base on ventral face and the other just in front and more dorsally. They are tipped by 2 short plumose spines respectively and the anterior pair has an additional one on lateral side. Abdomen small, wider than long, fused with genital segment, with entire lateral and V-shaped posterior borders.

First antennae have distal joint proportionally somewhat longer than in other sex. Terminal joint of 2nd antennae reduced into a small prehensile claw, which is curved, narrowed to the tip, turned back over 2nd joint and bears a spinule on inner face; 2nd joint broad, elongate, with 2 semicircular tubercles on anterior face near the base of claw. Second maxillae with broad base, but attenuated towards the blunt, club-shaped tip where they bear narrow, lunular flap on each side and transverse striations on the surface. Structure of 2nd maxillipeds resembling that of female, but relatively feebler. Caudal rami short, their apices round, broader than their bases, bearing each 3 very long as well as 3 very short plumose spines; Inner border with a row of cilia. Other appendages as in the female.

Remarks

The genus *Anuretes* was erected by HELLER for the reception of *heckeli* which had formerly been placed in *Lepeophtheirus* by KRØYER. The principal reason for which this species was rejected from the latter was the complete absence of the abdomen. The 2 new species described above have the distinct abdomen though in a rather rudimentary condition. There is a certain probability, therefore, that they may belong to *Lepeophtheirus* where this part of the body is well developed.

But, the generic limits of *Anuretes* appear to have been gradually extended in accordance with the increase of the species to be assigned to this genus. In *heckeli* KRØYER, the type of the genus, the abdomen is said to be entirely missing, while in *perplexus* BASSETT-SMITH, *parvulus* WILSON and *plectorhynchi* YAMAGUTI there is on the ventral surface of the genital segment a structure which can be regarded as the remnant of the abdomen. Further, *parvulus* has a distinct and relatively large-sized abdomen in younger stages, and this becomes absorbed step

by step by the genital segment as the body grows larger. The abdomen in *renalis* Heegaard recently reported from Japan is much larger than that known to any of the *Anuretes* species and is distinctly separated from the genital segment. In either of the 2 new species described above, it is smaller than that of *renalis* and is completely coalesced with the foregoing segment. Although *renalis* appears to have been assigned to *Anuretes* by that author with some doubt, if his assignement is appropriate, the 2 new species in question will naturally fall within the confines of this genus. But, such a small abdomen as found in them can also be discovered in the genus *Lepeophtheirus*. The abdomen of *L. dissimulatus* Wilson, or of *edwardsii* Wilson, or of *goniistii* Yamaguti, for example, is only a little longer than that of *A. quadrilaterus*. Besides, the gradual degeneration of the abdomen such that observed in *parvulus* can not be discovered at all in both of the present species, despite the careful examination of all the specimens in my hand.

There are, nevertheless, many points in the 2 species on account of which these can not be placed in *Lepeophtheirus*. In this genus, the 4th pair of thoracic legs is always 4-segmented. While, in one of the new species, namely in *serratus*, this pair is 3-segmented, and in the other, *quadrilaterus*, it is composed of only 2 segments. The distal segment of this limb pair in the latter bears clear marks which indicate that it is formed by the fusion of 2 segments. These are the presence of a spine on the outer border of this segment and the arrangements of the muscles present within. But, the segment shows the least sign of it being composed by the union of 4 segments. The species of *Anuretes* except *parvulus* and *renalis* possess the 3-segmented 4th legs. In *renalis* these are 4-segmented, and on account of this I am somewhat doubtful in placing it within *Anuretes*. In *parvulus* they are also 4-segmented, but the line of articulation between the 2nd and the 3rd segments follows a rather unusual direction.

The free thoracic segment bearing the limb pair in question is distinctly separated from the carapace in *Lepeophtheirus*, usually interposing between them a more or less narrow space. In *Anuretes* the carapace and the 4th thoracic segment are contiguous in many cases and the latter is partly or entirely concealed beneath the former, though separated in some other cases. The 2 new species agree with the major part of the genus in this respect.

In addition to these, they go beyond the confines of *Lepeophtheirus* in some other points. In *serratus*, the sternal furca is absent as in *A. brevis* Pearse and the mouth tube is slender as in this and in *parvulus*. In *quadrilaterus* the 2nd maxillae are simple unlike the species of *Lepeophtheirus*, but like *heckeli*, *perplexus*, and *plectorhynchi* of *Anuretes*.

As it may be noticed in the diagram inserted below, all of the hitherto known species of *Anuretes* are not necessarily in accord with one another in all

important points. In none of the characters, all of them are in complete agreement. But, if in one point, for example, species *A* conforms to *B*, but not to *C*, in another *A* is in common with *C*, but not with *B*. Strictly speaking, the species of the genus should be divided into several groups, each of which deserves a new genus. In the present state of things, this genus appears as if serving as a waste-basket for such species that can not be located in *Lepeophtheirus*. Smallness of the number of belonging species keeps us from dividing it into several genera.

From those reasons enumerated above, it appears to me appropriate, for the present, to modify and extend the definition of *Anuretes* as follows: The abdomen is rudimentary and united with the genital segment; the 4th thoracic legs are usually composed of less than 4 segments. As may be clear from the table below, *Anuretes* is a genus which has undergone a certain degree of degeneration from *Lepeophtheirus*, separately in various parts of the body, and its abdomen is most strikingly arrested in development.

The principal points of differences found among the known species of *Anuretes* and between these and either of the new species will be tabulated below. The table may at the same time be subservient for combining them together in a single genus.

	Mouth tube	1st maxilla	2nd maxilla	Sternal furca	4th thoracic segment	Number of joints of 4th legs	Abdomen
heckeli	broad	present	simple	present	distinct	3	absent
perplexus	broad	present	simple	present	distinct	3	hidden under genital segment
parvulus	slender	absent	in the state of stub	in the state of stub	distinct or almost concealed	4	hidden under genital segment
plecto-rhynchi	broad	present	simple	present	concealed	3	hidden under genital segment
brevis	slender	present	bifid	absent	distinct	3	absent
renalis	?	present	bifid	absent	partly concealed	4	distinct
serratus	slender	present	bifid	absent	partly concealed	3	fused with genital segment
quadri-laterus	broad	present	simple	present	partly concealed	2	fused with genital segment

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Copepods Parasitic on Japanese Fishes

4. The Family Euryphoridae

(With 6 Text-figures)

SUEO M. SHIINO
Faculty of Fisheries, Prefectural University of Mie

In this article, *Gloiopotes longicaudatus* (MARUKAWA), *Elytrophora brachyptera* GERSTAECKER, and *Euryphorus nympha* STEENSTRUP & LÜTKEN are treated. They are the whole of the representatives of the family Euryphoridae known to occur in Japan, and all were recorded by YAMAGUTI (1936). The first of them was described by him in detail, but it was not provided with any definite specific name, having been called merely *Gloiopotes sp.* It was in complete agreement in its characters with the species which had been published by MARUKAWA (1925) under the name of *Caligus longicaudatus* MARUKAWA. Although the designation of the genus by this author was misleading, his specific name is valid and should be retained. The species is rejected from the erroneous genus and transferred to the one where it ought to be placed. The second species was admirably portrayed by YAMAGUTI, but was not provided with any description, and so a detailed account is given here. The third was reported by the same author as *Euryphorus coryphaenae.* This name must be replaced by *nympha*, the one proposed 2 years earlier than *coryphaenae.* My collection of this form includes some immature specimens which have been heretofore unknown, and these are described also.

Genus *Gloiopotes* STEENSTRUP & LÜTKEN, 1861

Gloiopotes longicaudatus (MARUKAWA), 1925

(Figs. 1 & 2)

Caligus longicaudatus, MARUKAWA, 1925, Illustrated Encyclopedia of the Fauna of Japan, p. 1243, fig. 2396 ; 1947, p. 927, fig. 2654.

Gloiopotes sp., YAMAGUTI, 1936, Parasitic Copepods from Fishes of Japan, pt. 3, p. 4, pl. ii, fig. 20, pl. iii, figs. 21–35.

Occurrence: On the surface of *Tetrapturus mitsukurii* JORDAN & SNYDER and *Parathynnus sibi* (TEMMINCK & SCHLEGEL) taken at Irôzaki point, Izu, Sizuoka Pref.; 2 females and 11 males. On *T. mitsukurii* obtained off Tanabe, Wakayama Pref.; 3 females and 3 males. On unknown host collected at Palao Isl. by F. UTINOMI ; 4 females and 1 male.

Distribution: Japan and Mariana: Momotori, Mie Pref. (YAMAGUTI), Pacific

coast of Japan (MARUKAWA). Hosts: Besides those above named, *Xiphias gladius* LINNÉ (MARUKAWA).

As both the sexes were precisely described by YAMAGUTI, here I confine

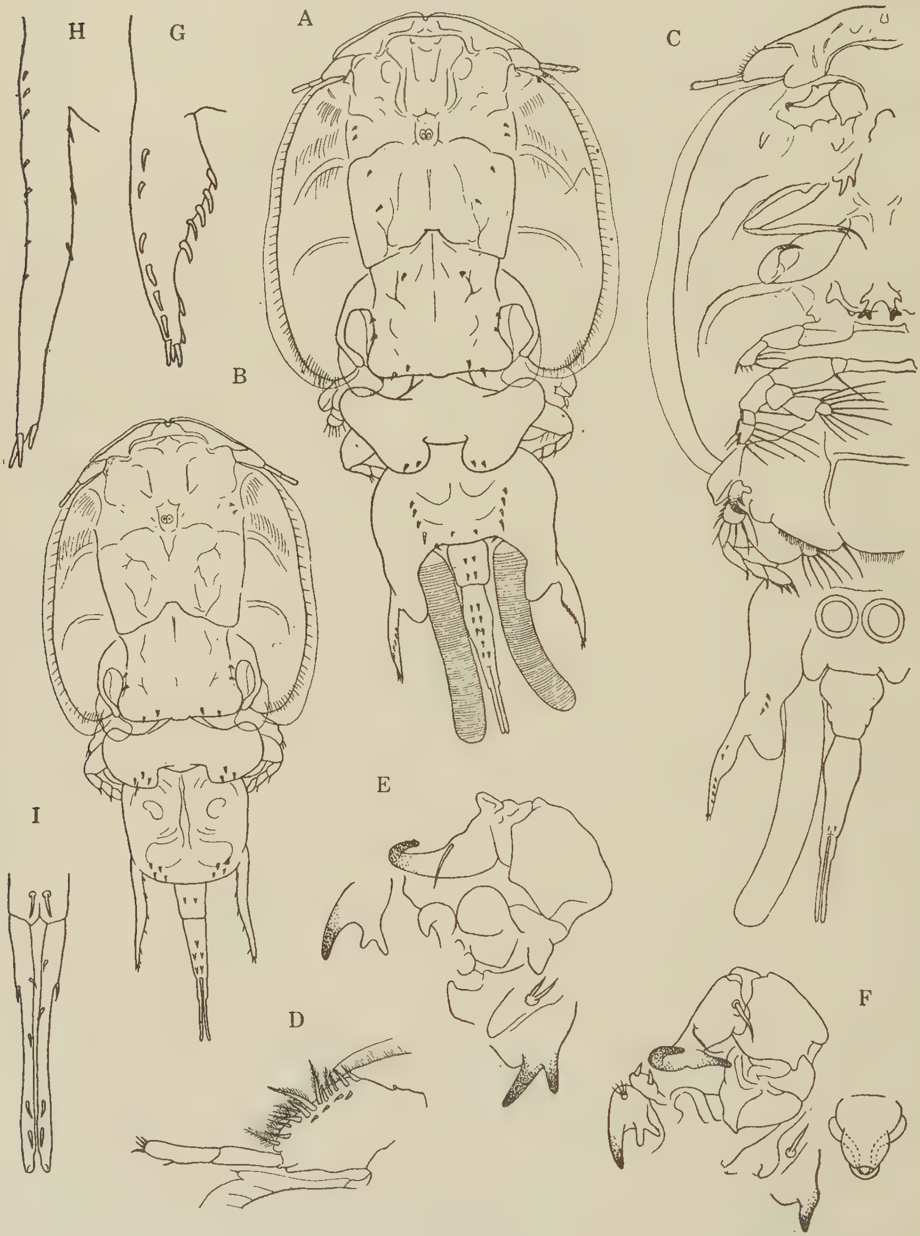


Fig. 1. *Gloiopotes longicaudatus* (MARUKAWA). A, female, dorsal view; B, male, dorsal view; C, female, ventral view; D, 1st antenna of female; E, 2nd antenna and maxillae of female; F, 2nd antenna, maxillae and oral tube of male; G, posterior process of genital segment of female; H, same of male; I, caudal ramus of female. A, B ×9.3, C ×12, D-I ×32.

myself to give a short account about the most distinctive features.

Female: Color purple to bluish purple in living state, egg strings pink-colored. Measurements in mm: Body length 10.2, carapace 5.1×4.6, width of median lobe 2.1, 4th thoracic segment (length on the mid-line) 1.0×2.9, genital segment, length on the mid-line 1.4, same, including lateral lobes 3.1×2.6, abdomen, length including caudal rami 2.7. Surface of segments with many spines disposed as shown in Fig. 1, A.

Carapace ovate, but with median posterior lobe truncate. Dorsal surface bears oblique rows of soft hairs on antero-lateral regions and similar hairs along borders of postero-lateral lobes. Transverse groove separating cephalic and thoracic areas arched anteriorly, but not reaching ocular area. Dorsal plates of 4th thoracic segment expanded antero-externally as well as postero-internally, each of them resembling an ear-lobe in shape. In some cases, posterior expansions are somewhat longer than those figured here, interposing a deeper median incision. Posterior lobe on either side of genital segment is compressed obliquely laterally, terminating in an oval end. But, it is produced again along its ventral margin in an acuminate process, which extends as far as the tip of abdomen, and is spiny along dorsal border as well as at the apex. The lobes are, at times, inclined towards the median more strongly than indicated in the accompanying figure and the apical processes diverge somewhat more strongly. Abdomen 2-segmented; 1st segment wider than 2nd, but half as long. Egg tubes attain tips of styliform caudal rami.

First antennae with distal joint divided into 2 false articles. Terminal claw of 2nd antennae with a round basal process on anterior side and a spine at about the middle of its length; basal joint with a broad, triangular posterior process. First maxillae tripartite, 2nd maxillae bipartite, sternal furca compound, all being exactly the same as those of *costatus* in structure. First maxillipeds slender and long, but with relatively short apical spines. Second maxillipeds stout, of usual prehensile form.

First thoracic legs with a bi-articulated rudimentary endopodite. Second legs with both rami 3-jointed; 1st joint of exopodite with striated chitinous membrane on outer border. Both rami of 3rd legs also with 3-jointed rami, basal article of endopodite rudimentary, lacking any spine, but same article of exopodite armed with bifurcated hook which is associated at the base with a short plumose spine. Fourth legs as those of *ornatus* and *costatus*. Disposition of spines and other armatures on each pair of legs may be clarified by the table inserted at the top of the next page*.

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* Abbreviations used in the table:
C, row of cirri; c, row of cilia; f, membraneous flange; H, longer simple spine; h, shorter simple spine; P, longer plumose spine; p, shorter plumose spine; rh, rudimentary spine; s, solitary hair.

Legs	Margins	Sternal plate	Protopodite	Exopodite			Endopodite		
				1st joint	2nd joint	3rd joint	1st joint	2nd joint	3rd joint
I	outer		1h	1h	3H, 1s			3s	
	inner			c	3P		1s		
II	outer	f		1H, f	1H	2H	c	c	
	inner		1P, 2h, 1s, f	1P, c	1P	6P	1P	c, 2P	6P
III	outer	f	f, 1H		1h	3h	c		
	inner		1P, 2s, f, c, 1p	1P	1P	5P	2P, c	4P	
IV	outer		1s	hh,C,1H	C, 1H	C, 3H, C			
	inner								

Male: Color as in female. Measurements in mm: Body length 8.9, carapace 4.3×3.6, width of median lobe 1.8, 4th thoracic segment (length on the mid-line) 0.8×2.3, genital segment, length on the mid-line 1.6, same, including lateral lobes 2.7×1.8, abdomen, length including caudal rami 2.2.

Carapace somewhat narrower than that of female, but resembling in general constitution. Dorsal plates of 4th thoracic segment smaller, nearly quadrilateral, but antero-lateral corners somewhat protruding, postero-internal ones angular, and postero-lateral ones well round. Genital segment squarish, with slightly convex hind border and produced on each side into a styliform process attaining near the tip of abdomen.

Curved terminal claw of 2nd antennae reenforced by a short, straight, vertically directed, accessory branch, and bearing a spine a little behind this as well as at the extreme base of claw. Second maxillae undivided. Otherwise as in the female.

Remarks: In describing the present parasite in 1936, Yamaguti did not give it any definite name, calling it merely *Gloiopotes sp.* But, he suggested that it resembles *G. ornatus* Wilson on one side and *G. costatus* Wilson on the other. Nevertheless, it presents several details, by which it can be discriminated from either of them, as this may be clear from the comparison made below. I believe it can stand as a distinct species.

Earlier than Yamaguti and in 1925, Marukawa published a piscicola copepod in the Illustrated Encyclopedia of the Fauna of Japan (Nihon Dobutu Zukan) under the name of *Caligus longicaudatus* Marukawa. His description in Japanese was too brief to give a notion of its distinguishing traits and his illustrations of both the sexes did not appear to be free from errors. And yet, it was well enough figured to show it being a *Gloiopotes.* The host fishes named by him were *Tetrapturus mitsukurii* and *Xiphias gladius.* As the former of these hosts is the one on which Yamaguti and I found the parasites treated above, there may be no doubt in that these are identical with *Caligus longicaudatus.* But, Maru-

KAWA's assignment to the erroneous genus should be amended, and the species ought to be transferred to *Gloiopotes*.

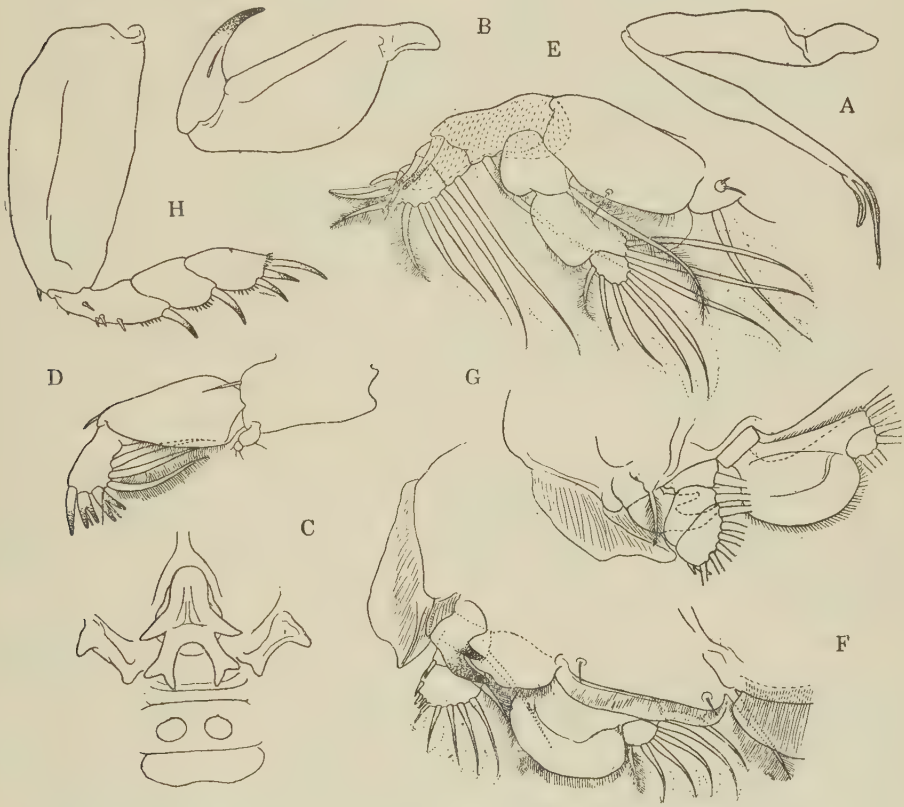


Fig. 2. *Gloiopotes longicaudatus* (MARUKAWA). A, B, D-H, female; C, male. A, 1st maxilliped; B, 2nd maxilliped; C, sternal furca; D, 1st swimming leg; E, 2nd leg; F, 3rd leg; G, same, posterior face; H, 4th leg. A-H ×32.

The present species bears a certain resemblance in its general constitution to *G. ornatus* as well as to *G. costatus* as pointed out by YAMAGUTI. In the characters of the female it appears to be closer to the latter. There are, however, many points by which it is distinguished from either of them. Above all, possession of rows of long hairs on the antero-lateral regions of the carapace is the most distinctive feature. But, as the hairs are very fine and colorless, there is a probability that they have been overlooked in the other species. In the configuration of the dorsal plates of the 4th thoracic segment, *longicaudatus* goes between *costatus* and *ornatus*. Those of the second species extend farther backwards than in the first, interposing a narrower, deeper sinus, while those in the third much less, leaving merely a very broad, shallow depression on the median. The present species is similar to *costatus* in the genital segment lacking the lateral spine rows which are present in *ornatus*. But, it agrees with

the latter on the other hand in that the posterior processes of this segment attain the end of the body, in contrast to the former where these remain to extend only a little beyond the centre of the abdomen. In the arrangement of spines on the abdomen, Japanese species has something in common with *costatus*, but in bearing spines on the surface of carapace and anterior segments it is similar to *ornatus*, and yet in their arrangement it is different from this species again.

As regards the male characters, *longicaudatus* is closer to *ornatus* than to *costatus*. In the first and the second species the dorsal plates of the 4th thoracic segment are more or less quadrangular, though in the first a wider sinus is inserted between them. In the third, they are circular. The posterior processes of genital segment attain the tip of abdomen in the first two, but they do not exceed the middle of this segment in the rest. Thus, generally speaking, Japanese species is more closely related to *costatus* in the characters of the female, but to *ornatus* in those of the male.

The three species can be discriminated one from another also by the disposition of spines on the 3rd thoracic legs as it may be clear from the following comparison:

	ornatus			*costatus*			*longicaudatus*		
Ordinal number of joints composing the rami of 3rd leg	I	II	III	I	II	III	I	II	III
Number of plumose spines present on the endopodite	2	5		1	3		2	4	
Number of plumose spines present on the exopodite	0	1	4	0	0	6	1	1	6
Number of simple spines present on the exopodite	0	1	2	0	0	0	1	1	3
Basal hook	bipartite			tripartite			bipartite		

The present species is less closely allied to other species of *Gloiopotes* rather than to the American species above compared. It is distinguished from them, above all, by the configuration of the dorsal plates on the 4th thoracic segment. In *hygomianus* Steenstrup & Lütken these are elongated covering the genital segment almost entirely. In *huttoni* (Thomson) these are much expanded in a pair of large oval plates which interpose between them a very small excavation. In *crassus* Wilson & Bere these are reduced into very small lobes, so that a greater part of the genital segment remains exposed. The last species is much different from all others also in many other respects.

Genus *Elytrophora* GERSTAECKER, 1853

Elytrophora brachyptera GERSTAECKER, 1853

(Figs. 3 & 4)

Elytrophora brachyptera, GERSTAECKER, 1853, Arch. f. Naturg., 19, p. 60, pl. iii, fig. 12; HELLER, 1865, p. 189, pl. xvii, fig. 1; BASSETT-SMITH, 1896, p. 12, pl. iv, fig. 3; BRIAN, 1906, p. 51, pl. i, figs. 2–3; 1912, p. 10; SCOTT, T. & A., 1913, vol. 1, p. 82, vol. 2, pl. xxiii, figs. 1–2, pl. xxxi, figs. 1–6.
Dinematura thynni, KOLLAR.
Arneus thynni, KRØYER, 1863, Naturh. Tidssk., 1863, p. 157, pl. viii, fig. 5.
Caligeria bella? DANA, 1848, Proc. Amer. Acad. Arts & Sci., p. 57.

Occurrence: On *Thynnus orientalis* (TEMMINCK & SCHLEGEL) purchased at Tyôsi Market, Tiba Pref.; on the same at Owase Market, Mie Pref.; on the same and on *Parathynnus sibi* (TEMMINCK & SCHLEGEL) taken off Irôzaki point, Sizuoka Pref. Numerous specimens of both sexes were found attached gregariously on the inner surface of gill operculum.

Distribution: Cosmopolitan. European coast of the Atlantic (BASSETT-SMITH, SCOTT), on *Thynnus thynnus*; Adriatic and the Mediterranean (BRIAN, GERSTAECKER, RICHARDI), on *Th. thynnus* and *Th. alaonga*. Pacific coast of Japan (YAMAGUTI), on *Th. orientalis* (probably not *Th. thynnus* as mentioned by that author).

In recording the present species from Japan, YAMAGUTI did not give any description except for the measurements of the body parts. He inserted excellent illustrations of the both sexes, but nothing was figured as regards the appendages.

Female: Elongate and depressed. Color pale brownish, with dark pigment spots on dorsal surface of entire body and on ventral side of genital segment. Measurements in mm: Body length 8.3, carapace 3.6×4.1, 4th thoracic segment 1.3×2.0, genital segment 2.1×1.9, abdomen, length 1.4, 1st abdominal segment 0.7×0.9, 2nd segment 0.7×0.7, egg strings 11.8.

Carapace orbicular, wider than long. Frontal plates half as wide as carapace, somewhat arched on the free margin, shallowly incised at the centre and brimmed with narrow membrane of chitin. Lateral areas rather broad, only slightly narrower than central area, 2 sides well curved, but slightly notched about the middle and with relatively narrow marginal rims. Posterior lobes well round, extending backwards a little beyond median lobe. Cephalic area has distinct eyes at the centre and thrusts into thoracic area, from which it is bordered by a V-shaped furrow. Paired longitudinal furrows diverge forwards, attaining lateral ends of the named furrow; their posterior halves arcuate. Cross-bar combining them straight and on the level of posterior quarter of carapace. Transverse grooves across the lateral areas are considerably in front of the cross-bar and reach the notches of lateral margins. Median lobe short and



Fig. 3. *Elytrophora brachyptera* GERSTAECKER. A, female, dorsal view; B, male, dorsal view; C, female, ventral view; D, 1st antenna of female; E, 2nd antenna, 2nd maxilla and oral tube; F, 2nd antenna of male. A ×11, B ×12, C ×18, D ×88, E, F ×38.

narrow, a little more than a quarter as wide as carapace, with truncate posterior border, but round at either corner.

Fourth thoracic segment connected with carapace by a short neck, but widening abruptly in a pair of dorsal plates which, joining together at the bases, form a trapezium. The latter nearly twice as wide as long, broader in front attaining half the width of carapace; antero-lateral angles round and posterior part divided into 2 oval lobes slightly overlapping each other. Genital segment about 3/4 as long as carapace, longer than wide, swollen dorso-ventrally, and

barrel-shaped having gracefully arched sides; hind margin produced on each side into an obovate lobe hanging over anterior end of following segment. Abdomen short, half as long as genital segment and half as wide, 2-segmented. First segment with more or less angular posterior corners; 2nd segment subequal to the 1st in length, but narrower, with round sides and an inconspicuous median lobe on hind border.

First antennae small, with distal joint shorter than the proximal, setose at the tip; the latter relatively narrower than usual, and with plumose spines along exposed anterior border. Apical joint of 2nd antennae slender, strongly curved, bearing a seta at about the middle of its length and a broader, but sharp spine close to the base; basal joint with acuminate, posterior process. First maxillae missing. Second maxillae with their tips undivided, curving outwards and narrowing each to a sharp point; they bear 2 minute basal spinules surmounting on a tubercle on either side. First maxillipeds slender; 2nd joint longer than 1st, with a triangular, striated accessory lobe a short distance removed from the tip and terminating in 2 unequal spines with finely serrated borders. Second maxillipeds powerful; palm inflated, with 2 small knobs on posterior side and a low elevation on inner margin against which the tip of strongly curved claw shuts. Sternal furca with branches long, straight and diverging in the form of a V.

All 4 pairs of thoracic legs biramous. Rami of 1st pair 2-jointed, with endopodite much smaller than exopodite. Succeeding 2 pairs as in other Caligids, with 3-jointed rami and expanded protopodite. Endopodite of last pair 2-jointed, and shorter than 3-jointed exopodite. Arrangement of spines and other armatures on each of them may be clarified by the following diagram:

Legs	Margins	Sternal plate	Protopodite	Exopodite			Endopodite		
				1st joint	2nd joint	3rd joint	1st joint	2nd joint	3rd joint
I	outer			1h	3H, 1P			C	
	inner		1s	c	3P			3P	
II	outer	f	1s	c, 1H	1H	2H, 1P	C	C	
	inner		1P, f	c, 1P	c, 1P	5P	1P	c, 2P	6P
III	outer	f	f	c, 1H	c, 1h	3h	c	c	
	inner		1P, f	c, 1P	c, 1P	5P	1P	c, 2P	4P
IV	outer		h	C, 1H	2C, 1H	2C, 3H	c	c	
	inner		(f)		1h	4h	1H	4P	

Of 4 terminal spines on exopodite of 1st legs, the longest one plumose, the shortest one with finely serrated, narrow fringes, and the rest simple. First exopod joint of 2nd legs with broad, striated membrane along outer border. The

longest one out of 4 external spines on 3rd joint has a row of fine hairs on inner side, but the hairs are united together to form a continuous sheet on the other side; the spine which comes next in length has merely a membraneous rim and others are simple. Exopodite of 3rd legs lacks basal hook. Same ramus

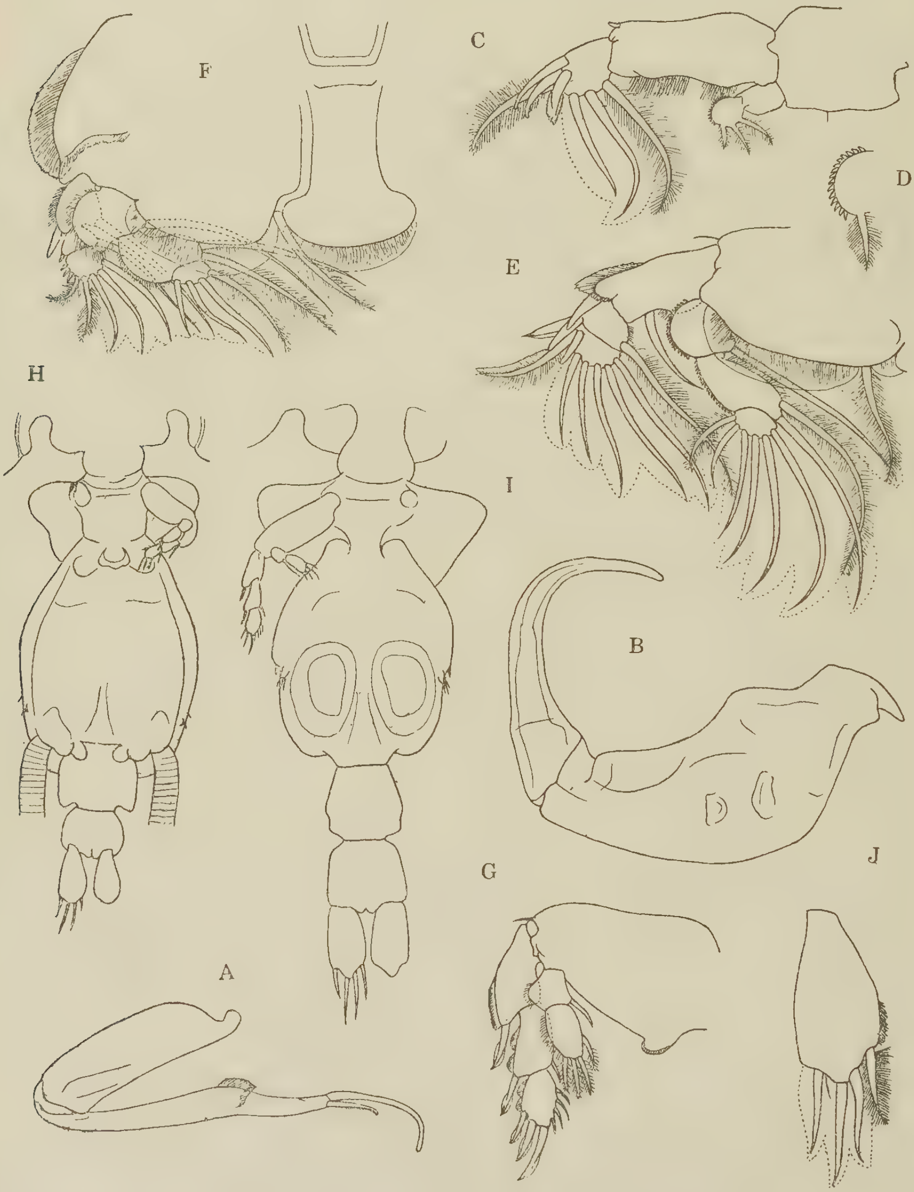


Fig. 4. *Elytrophora brachyptera* GERSTAECKER. A-H, J, female; I, male. A, 1st maxilliped; B, 2nd maxilliped; C, 1st leg; D, endopod of same, further enlarged; E, 2nd leg; F, 3rd leg; G, 4th leg; H, posterior segments of female, ventral view; I, same of male, ventral view; J, caudal ramus. A-C, E-G, J ×38; D ×73; H ×12, I ×18.

of last pair of legs has continuous fringe formed by union of short cirri on outer border of each joint, while other ramus bears a row of separate setae on the corresponding border. Spines on outer border of the former with narrow lunular rims. Protopodite provided with a small bulge brimmed by fine cirri on posterior border. A few spines found on lateral margin of genital segment near the hind end probably represent rudiments of 5th limbs.

Caudal rami obovate, narrowing towards the base, with length equaling to that of 1st abdominal segment. Each of them bears 4 plumose spines and a seta at the apex and a row of fine hairs on inner border.

Male: More or less resembling female. Measurements in mm: Body length 6.0, carapace 3.3×3.1, 4th thoracic segment 0.8×1.7, genital segment 1.5×1.3, abdomen, length 1.0, 1st abdominal segment 0.5×0.6, 2nd segment 0.5×0.5.

Carapace somewhat narrower than in other sex, longer than wide. Lateral margins somewhat uneven in anterior parts besides with the central notch. Median lobe slightly convex on free border. Dorsal plates of 4th thoracic segment relatively broader than in female, but shorter, and much narrowed backwards. Genital segment somewhat different in structure from corresponding segment of female. It is less than half as long as carapace. Its narrowed anterior end forms a pair of small round knobs, between which a short neck is inserted to be connected with 4th segment. Lateral margins slightly converging backwards. Posterior border without dorsal lobe and more or less angular at each corner. Abdomen 2/3 as long as and less than half as wide as genital segment. It is composed of 2 subequal segments; anterior one somewhat narrowed forwards, while posterior one squarish, with a small median process.

Apical claw of 2nd antennae bears a short accessory process and a seta somewhat behind the centre, in addition to the basal spine. Genital segment has a short spine and a small process surmounted with a few setae on either lateral side about the centre. These probably represent the rudiment of 5th limb. In other respects as in the female.

The sexes for the most part were pairing. The male hangs from the genital segment of the female backwards, holding it with the 2nd antennae and the 2nd maxillipeds and turning ventral side towards the same side of the female.

Remarks: It is rather astonishing that the Japanese specimens are largely in accord with the European ones described and figured by GERSTAECKER and by T. & A. SCOTT, and with the illustration given by BRIAN. Although somewhat different in the outline of the segments, they are in agreement in the structure of the appendages, especially in that of the 1st and the last pairs of legs. WILSON, in 1921, described the second species *E. hemiptera* from Nagasaki, Japan, based on the single parasite of unknown host. In general appearance as

well as in the proportion of the body parts, my specimens are in strict accord with his species, and seem closer to this species than to European specimens of *brachyptera*. The two lots of Japanese specimens Wilson's and mine appear at first sight to be con-specific. Nevertheless, there are a number of important discrepancies between them in the structure of thoracic legs.

In my specimens, the 4 apical spines on the exopod of the 1st legs are divisible into a long, plumose one and a group of short, subequal, non-plumose 3, while in Wilson's species they consist of longer, subequal 3 and much shorter 1, all being non-plumose. This pair of legs bears a spine on the anterior edge of the protopodite in the latter, but is spineless in the former. The endopodite of this pair is represented as being unsegmented in Wilson's figure of *hemiptera*. This may probably be due to the fault in his examination. His species has 7 apical spines and a basal one on that ramus, while my specimens possess 6 spines at the apex, 2 on the 2nd joint and 1 on the basal joint, in all 9. Apical as well as basal articles of the exopod of that species lack the external spine and the 2nd article alone bears 2 short and a much longer non-plumose spines. But, here, the distal joint has a longer and 2 shorter spines, and the proximal 2 carry each an external spine which is plumose on one side and bears a membrane on the other. The 4th legs of *hemiptera* have a short spine on the basal exopod joint on the outer border close to the base. This spine is replaced in my specimens by the one present at the outer distal angle of protopodite. Apical exopod joint of *hemiptera* has 3 spines on the inner border instead of 4 of the present specimens, and 2 spines on the inner border of the endopod are reduced into 1 in the latter.

Such differences in the disposition of spines between the legs of the two forms may be ascribed to the incompleteness of the examination of *hemiptera*, or to the defect in its preservation condition. It might be probable that my specimens are identical with Wilson's. But, I hesitate to refer the present specimens to *hemiptera* when there are such grave disagreements between them. Until we have more accurate knowledge of *hemiptera*, it appears to me appropriate, for the present, to assign my specimens to the well-known *brachyptera* with which they are in complete agreement in the structure of appendages.

Genus *Euryphorus* M.-EDWARDS, 1840

Euryphorus nympha STEENSTRUP & LÜTKEN 1861,

(Figs. 5 & 6)

Euryphorus nympha, Steenstrup & Lütken, 1861, Dansk. Vidensk. Selsk. Skrift., (5) vol. 5, p. 365, pl. vi, fig. 12; Bassett-Smith, 1899, p. 461.

E. coryphaenae, Krøyer, 1863, Naturh. Tidssk., (3) vol. 2, p. 161, pl. x, fig. 4; Wilson, 1913, p. 225; Yamaguti, 1936, p. 1, pl. i, figs. 1-17.

Occurrence: On *Neothynnus macropterus* (TEMMINCK & SCHLEGEL) caught at Simakatu, Sima, Mie Pref. Numerous specimens attached gregariously on the inner surface of the gill operculum; younger individuals found scatterdly on the outside surface of the fish body.

Distribution: West Indies (STEENSTRUP & LÜTKEN, KRØYER) and Japan (YAMAGUTI). Parasitic on *Lampugus punctulatus* and *Coryphaena hippurus*.

The species was precisely described by YAMAGUTI under the name of *E. coryphaenae*. I here confine myself to give a short account as regards the principal points of its characteristics. Some young stages represented in my collection are to be described in addition.

A remarkable sexual dimorphism is observed.

Female: Pale grayish yellow, scattered with granules of black pigment on carapace, 4th thoracic segment and dorsal plates of genital segment. Main part of genital segment, abdomen and its lateral wings grayish white, lacking black pigment. Measurements in mm: Body, length from anterior end to abdomen 13.5, up to apices of abdominal wings 14.2, carapace 3.7×4.2, frontal plates, width 1.9, median lobe, width 1.3, 4th thoracic segment, length on the mid-line 0.6, same, including dorsal plates 1.1×1.8, genital segment 2.9×3.7, 1st abdominal segment, length on the mid-line 4.0, same, including lateral wings 7.4×5.0, 2nd segment 2.5×0.6, egg strings 20.1.

Carapace orbicular with round anterior and lateral borders. Longitudinal dorsal grooves nearly parallel and combined with each other by nearly straight transverse groove. Posterior lobes broad, well-round, extending a little beyond median lobe which is truncate on free border and 1/3 as broad as carapace. Eyes distinct, placed a little in front of the centre of cephalic area which is bordered from thoracic area by sinuous V-shaped groove. Dorsal plates of 4th thoracic segment small, ovate and separated from each other by a broad rectangular posterior sinus. Genital segment circular in outline and with a small, crescent dorsal plate on either side of its hind margin. Abdomen elongate, about as long as the rest of body, 2-segmented. First segment occupies 3/5 the length of abdomen on the mid-line, but expands posteriorly and laterally forming a pair of wing-like lobes which surpass the end of 2nd segment. The latter narrow, band-like, with a truncate end.

Distal joint of 1st antennae relatively thick and short; proximal joint narrower than usual. Apical joint of 2nd antennae elongate, strongly curved, with a basal spine and a seta at about the centre; basal joint reenforced by strong, acuminate process. First maxillae undiscovered. Second maxillae unforked, sharply narrowing apically, and with a spinulose, basal papilla. First pair of maxillipeds with a foliaceous, striated membrane on distal joint a distance behind its tip, besides with unequal apical spines. Second pair stout, palm with a small

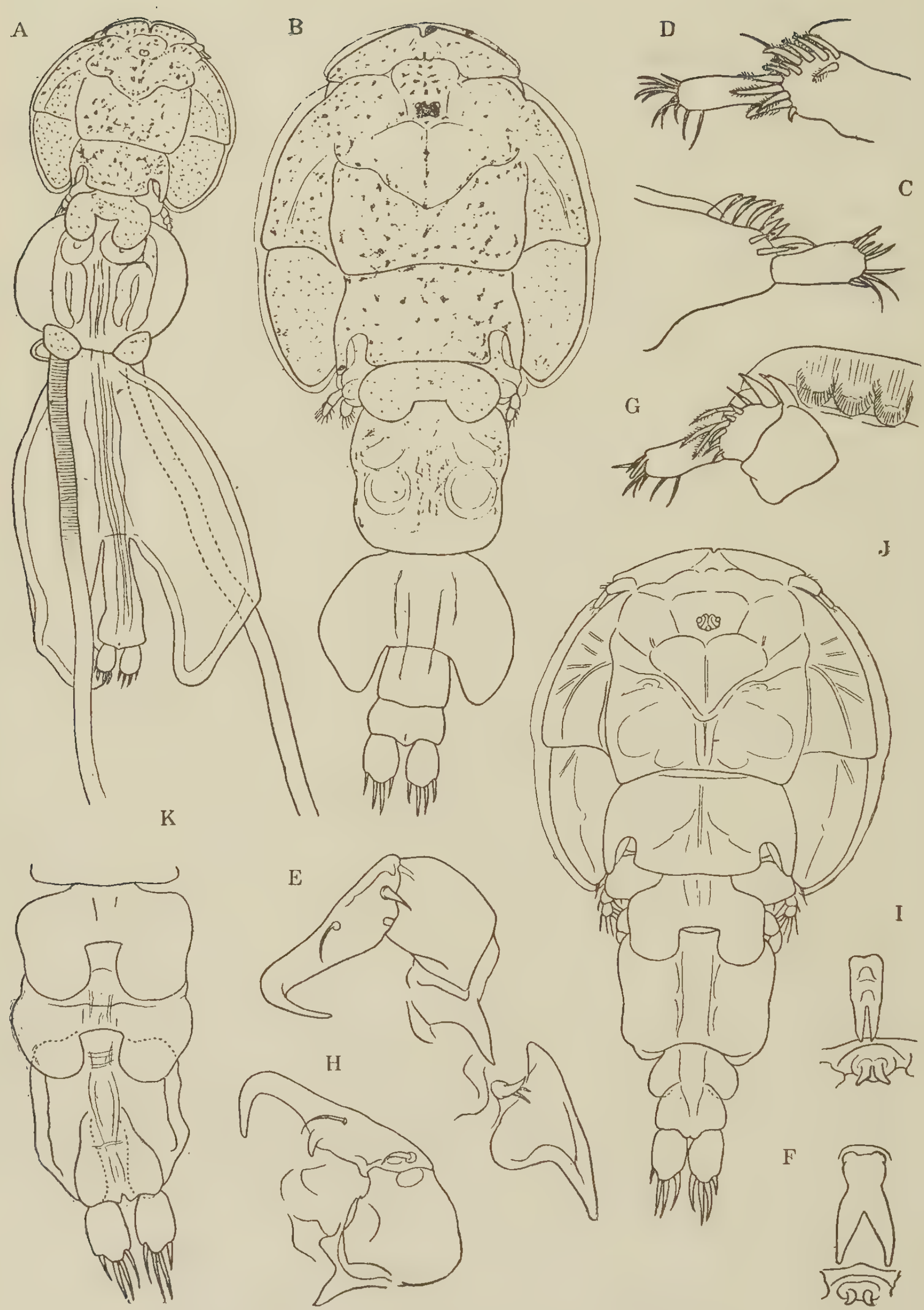


Fig. 5. *Euryphorus nympha* Steenstrup & Lütken. A, female, dorsal view; B, male, dorsal view; C-F, female; C, 1st antenna, dorsal view; D, same, ventral view; E, 2nd antenna and 2nd maxilla; F, sternal furca; G-I, male; G, 1st antenna, ventral view; H, 2nd antenna; I, sternal furca; J, younger male, dorsal view; K, posterior segments of younger female, dorsal view. A ×6.3, B, J, K ×19, C-E, G, H ×83, F, I ×41.

process on posterior side and a bulge showing rugged surface on the region against which well-curved, sharp claw closes. Sternal fork with 2 arms diverging in the form of a V.

All 4 pairs of thoracic legs biramous. Endopodite of 1st pair much rudimentary, but composed of 2 distinct segments as in exopodite. Both rami of succeeding pairs 3-jointed except for the last where endopodite consists of 2 segments. Number and arrangement of spines and other armatures on the legs are indicated in the following formula:

Legs	Margins	Sternal plate	Protopodite	Exopodite			Endopodite		
				1st joint	2nd joint	3rd joint	1st joint	2nd joint	3rd joint
I	outer		1p	1h	3H, 1P			C	
	inner		1p	c	3P			3p	
II	outer	f	c, 1p	f, 1H	1H	2H, 1P	C	C	
	inner		1P, f, 1s	c, 1P	c, 1P	5P	1P	c, 2P	6P
III	outer	f	f	c, 1H	1h	3h	c	c	
	inner		1P, f	c, 1P	c, 1P	5P	1P	c, 1P	4P
IV	outer			C, 1H	C, 1H	3H	c	c	
	inner				1P	4P	1P	4P	

Most of simple spines on the legs are serrated along their 1 or 2 borders, or with finely serrated, narrow rims. Most distal one of 3 external spines on apical exopod joint of 2nd limbs has inner border ciliated, but outer border rimmed with narrow, lunular membrane which is finely serrated on free margin. Caudal rami ovate ; inner margin ciliated, distal border uneven, bearing 4 plumose spines and a short simple one placed between the outermost spine and the adjoining one.

Male: Coloration as in female, but genital segment spotted with black all over its surface though rather sparsely. Measurements in mm: body length 5.2, carapace 2.4×2.4, frontal plates, width 1.4, median lobe, width 0.9, 4th thoracic segment, length on the mid-line 0.3, same, including dorsal plates 0.5×1.0, genital segment 1.1×1.1, 1st abdominal segment, length on the mid-line 0.7, up to the apices of lateral wings 1.0×1.4, 2nd segment 0.4×0.5, 3rd segment 0.3×0.6.

Carapace slightly narrower than in female. Fourth thoracic segment with paired dorsal lobes somewhat shorter and apart from each other a little farther than in female. Genital segment half as long as carapace, more or less quadrate, with round 4 corners and sinuous sides. Abdomen about 2/3 as long as carapace, 3-segmented. First segment occupying half the length of abdomen on the mid-line, and with wing-like lateral expansions which are incomparably smaller than

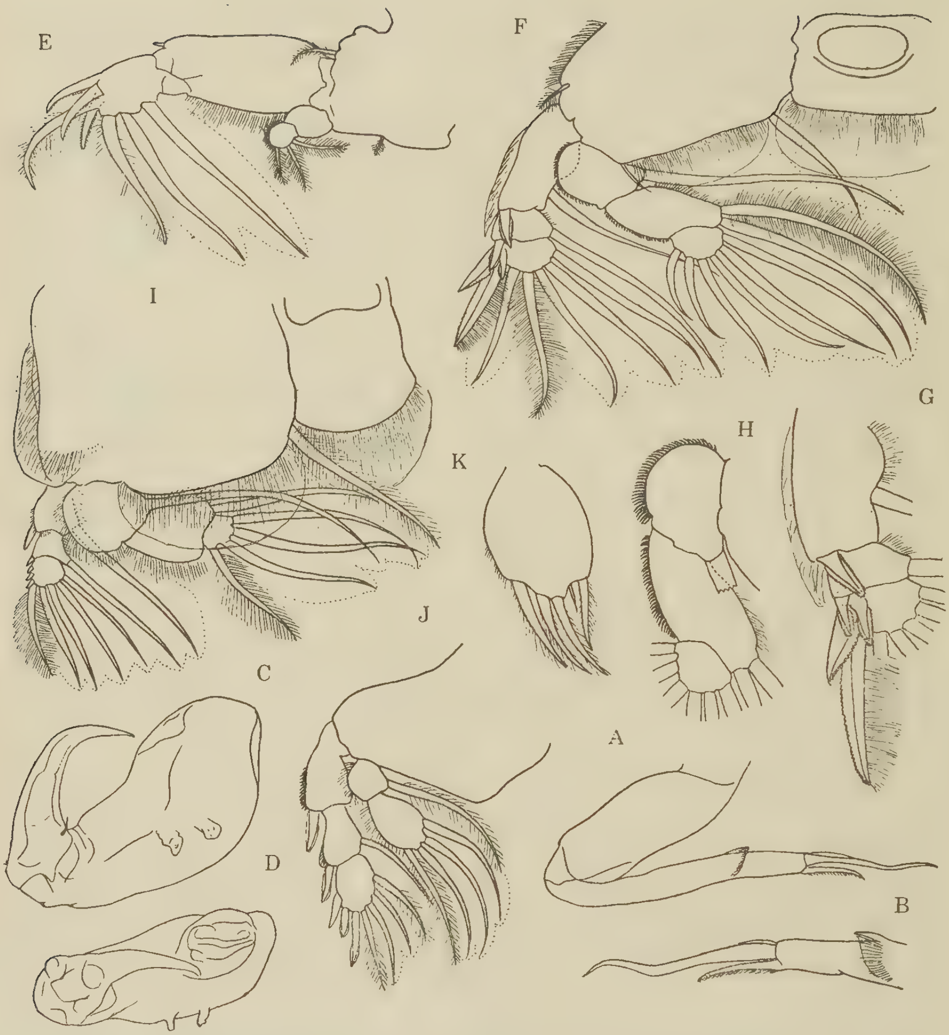


Fig. 6. *Euryphorus nympha* Steenstrup & Lütken. A-C, E-K, female; D, male. A, 1st maxilliped; B, tip of same; C, 2nd maxilliped; D, same of male; E, 1st leg; F, 2nd leg; G, exopod of same, further enlarged; H, endopod of same, further enlarged; I, 3rd leg; J, 4th leg; K, caudal ramus. A, C, D, K ×42, B, F, I, J ×62, E, G, H ×83.

those of female, and slightly shorter than genital segment. Succeeding 2 segments quadrangular; anterior one about as long as wide and longer than posterior one which is twice as wide as long.

Peduncle of 1st antennae composed of 2 false joints; distal one of these with a number of thin, plumose spines along anterior border and a thicker, non-plumose one at the base, proximal one only with the thick one at anterior angle. Apical joint of 2nd antennae bears a small accessory spine about the centre of

inner margin besides with ordinary setae. Sternal fork with 2 arms parallel with each other, interposing a very narrow sinus. In other points as in the female.

In majority of cases, the sexes were pairing. The male holds the female body with the 2nd maxillipeds, hanging the genital segment of the latter, and the both sexes turn their ventral sides to each other, directing their bodies towards the same direction.

The present collection includes a number of young specimens of both sexes. They were found on the outside surface of the fish body.

Young female (Fig. 5, K): Without black pigment. Measurements in mm: Body length 5.1, carapace 2.7×2.8, frontal plates, width 1.6, median lobe, width 1.1, 4th thoracic segment, length on the mid-line 0.4, same, including dorsal plates 0.8×1.3, genital segment, length on the mid-line 0.6, same, including dorsal plates 1.0×1.3, 1st abdominal segment, length on the mid-line 0.6, same, including lateral wings 1.3×1.1, 2nd segment 0.7×0.6.

Anterior part of body as in the adult, but posterior part relatively much smaller. Genital segment nearly quadrangular, about as long as wide, with a pair of proportionally large, oval dorsal plates on posterior side. First abdominal segment flattened, a little narrower than preceding segment, with rudiments of lateral wings in the state of a pair of posteriorly directed, linguiform lobes. Second segment short, triangular, and inserted between the wings of 1st segment. Appendages as in the mother individual.

Young male (Fig. 5, J): Body 4.3, carapace 2.4×2.4, frontal plates, width 1.4, median lobe, width 0.9, 4th thoracic segment, length on the mid-line 0.4, same, including dorsal plates 0.6×1.0, genital segment 0.9×1.1, 1st abdominal segment, length on the mid-line 0.3, same, including dorsal plates 0.4×0.6, 2nd segment 0.4×0.5.

Carapace resembles that of female. Dorsal plates of 4th thoracic segment unlike those of the mature male, but like those of young females in outline. Genital segment squarish, without dorsal plates. First abdominal segment with lateral wings much rudimentary. Last segment cordiform, not yet divided into 2 segments.

Remarks: The parasites above described are those which were recorded by YAMAGUTI (1936) under the name of *Euryphorus coryphaenae* KRφYER. This species, however, has been synonymized by BASSETT-SMITH (1899) with *E. nympha* published by STEENSTRUP & LÜTKEN two years earlier (1861) than KRφYER (1863). Although the original description of *coryphaenae* is inaccessible to me, the present parasites are in agreement with STEENSTRUP & LÜTKEN's species. I prefer the name *nympha* for them to *coryphaenae*.

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Copepods Parasitic on Japanese Fishes

5. Five Species of the Family Pandaridae

(With 19 Text-figures)

SUEO M. SHIINO
Faculty of Fisheries, Prefectural University of Mie

Members of the family Pandaridae are exclusively the parasites of sharks. Of five species of this family treated in this article, *Demoleus latus* n. sp. is the second species of the genus and *Echthrogaleus denticulatus* SMITH is recorded for the first time from our country. The males of the latter species and of *Pandarus satyrus* DANA to be reported here have been unknown to us. Descriptions of *Echthrogaleus coleoptratus* GUÉRIN and *Dinematura latifolia* STEENSTRUP & LÜTKEN are based on the specimens found on new hosts.

Genus *Echthrogaleus* STEENSTRUP and LÜTKEN, 1861

Echthrogaleus coleoptratus (GUÉRIN), 1817

(Figs. 1–3)

Dinematura coleoptrata, GUÉRIN, 1817, Régne animale de Cuvier, pl. xxxv, fig. 6.
Pandarus alatus, JOHNSTON, 1836, Lond. Mag. Nat. Hist., viii, p. 202.
Dinemoura alata, MILNE-EDWARDS, 1840, Hist. Nat. Crust., iii, p. 464.
Echthrogaleus coleoptratus, STEENSTRUP & LÜTKEN, 1861, Vidensk. Selsk. Skrift., math.-naturh., v, p. 380, pl. viii, fig. 15; OLSSON, 1868, p. 20; BASSETT-SMITH, 1899, p. 464; BRIAN, 1906, p. 53, pl. ii, fig. 2; 1908, p. 4; 1912, p. 12; WILSON, 1907, p. 367, pl. xix; 1908, p. 452; 1923, p. 13; 1932, p. 427, pl. xxvii; STEBBING, 1910, p. 559; T. & A. SCOTT, 1913, p. 89, pl. xxiii, fig. 4; HANSEN, 1923, p. 33; YAMAGUTI, 1936, p. 7, pl. iv; MARUKAWA, 1927, p. 1242, fig. 2394; 1947, p. 926, fig. 2652.

Occurrence: On the floor of buccal cavity and on the body surface of *Isuropsis glauca* (MÜLLER & HEULE) taken at Owase market, Mie Pref.; 5 females, no male.

Distribution: The species has an enormously wide range of distribution and is parasitic on various species of sharks. N. Atlantic (STEENSTRUP & LÜTKEN), North Sea (JOHNSTON), Bohuslän (OLSSON), Faroe Isl. (HANSEN), English and Scottish waters (SCOTT), Mediterranean (BRIAN), S. Africa (STEBBING), Woods Hole (SMITH, WILSON), Unalaska (WILSON), Indian Ocean (JOHNSTON, MILNE-EDWARDS), Mariana (OLSSON), and Japan (YAMAGUTI, MARUKAWA). On *Lamna cornubica*, *Carcharias glaucus*, *Carcharodon rondeleti*, *Carcharhinus milberti*, *Centrophorus granulosus*, *Scymnus lichia*, *Isurus dekayi*, *I. tigris*, *Acanthiae vulgaris*, *Prionace*

glauca and *Orthagoriscus mola.*

The species was repeatedly described by authors (Steenstrup & Lütken 1861, T. & A. Scott 1913, Wilson 1907, 1932) and the Japanese specimens were precisely studied by Yamaguti (1936). So, I here confine myself to give a brief account as regards the most important features, the differences from the descriptions of the past, or the points which have not been alluded.

Female: Dull grayish yellow, darker on the dorsal surface rather than on the ventral; carapace and dorsal plates of 4th thoracic segment chest-nut brown, but, at times, nearly colorless; genital segment dark grayish. Measurements in mm: Body length 11.5, carapace, including lateral lobes 4.8×5.2, same, length on the mid-line 4.1, frontal plates, width 3.4, 2nd thoracic segment, including lateral lobes 0.9×3.5, same, length on the mid-line 0.2, 3rd segment 0.6×2.3, 4th segment, length on the mid-line and width at the base 3.9×4.2, same, width at the widest region 5.8, genital segment, length on the mid-line 3.4, same, including posterior lobes 5.8×4.5, abdomen 1.5×1.7.

Carapace orbicular, slightly wider than long, including posterior lobes. Frontal plates narrow, arched anteriorly, with a shallow median incision and much rudimentary rims. Lateral areas less than 1/3 as wide as central area, round on margin, but with an inconspicuous notch at about the centre, and with relatively norrow rims. Posterior lobes not reaching dorsal plates of 4th thoracic segment. Hind magin of carapace somewhat convex, with a pair of small rims, one at each extreme lateral end. Eyes in front of the centre of carapace.

Second thoracic segment distinctly separated from 3rd unlike other species of the genus. Lateral lobes of 2nd segment quadrate, with a small spine-like process at antero-lateral angles on ventral surface, but round at posterior angles. They extend postero-laterally and covered by posterior lobes of carapace slightly. The segment bears a membraneous lobe around lateral and posterior borders on each side, but lacks it in the central part. Third segment has much shorter lobes, which end on either side in a papilliform process fringed with short hairs. Dorsal plates of 4th segment much enlarged, covering anterior half of genital segment and separated from each other from the very bases. They have a ventrally directed spine at each antero-lateral corner and very fine denticles along posterior margins. Transparent dots scattering over their dorsal surface are defined in darkly colored specimens, but hardly perceptible in uncolored ones. Genital segment longer than carapace, bilobed posteriorly, 2 lobes round at the tips, occupying 2/5 the entire length of segment. Those of 2 sides closely appressed on the median, or parallel with each other, or slightly overlapping. Sixth segment small, elliptical, placed at the bottom of median sinus of genital segment with which it is fused. Abdomen hexagonal, attached to ventral surface of genital segment.

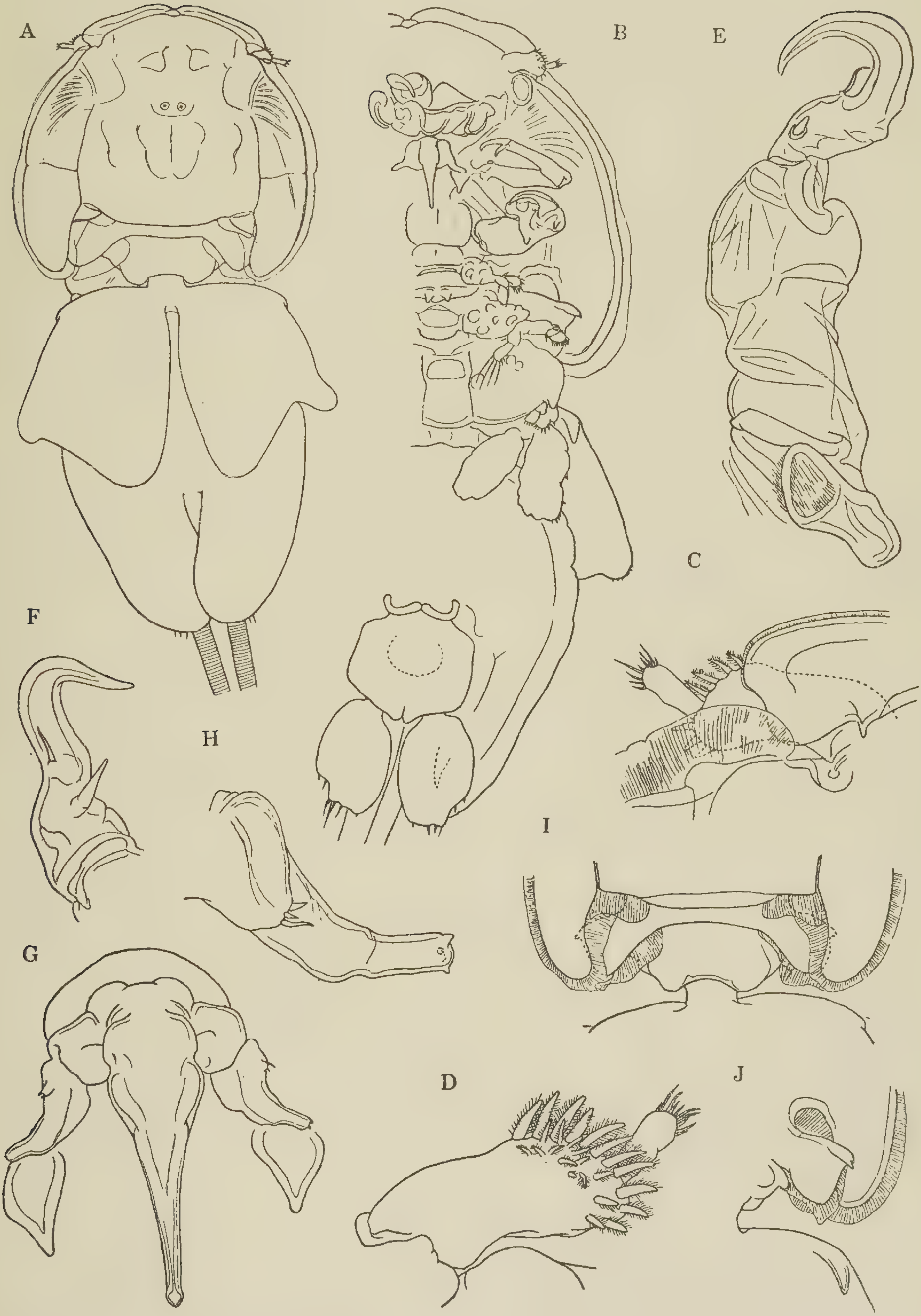


Fig. 1. *Echthrogaleus coleoptratus* GUÉRIN, female. A, female, dorsal view; B, same, ventral view; C, 1st antenna, dorsal view; D, same, ventral view; E, 2nd antenna; F, tip of same; G, oral tube, 2nd pair of maxillae, and adhesive pads at the bases of 2nd maxillipeds; H, 2nd maxilla, further enlarged; I, posterior part of carapace and free thoracic segments; J, lateral part of same, ventral view. A ×7.3; B, I, J ×10; C, E-G ×41; D ×52; H ×120.

Distal joint of 1st antennae 1/3 as long as proximal one. Terminal claw of 2nd antennae with a short seta at about the centre and a stronger spine near the base. First maxillae wanting. Second maxillae arise from a pair of round

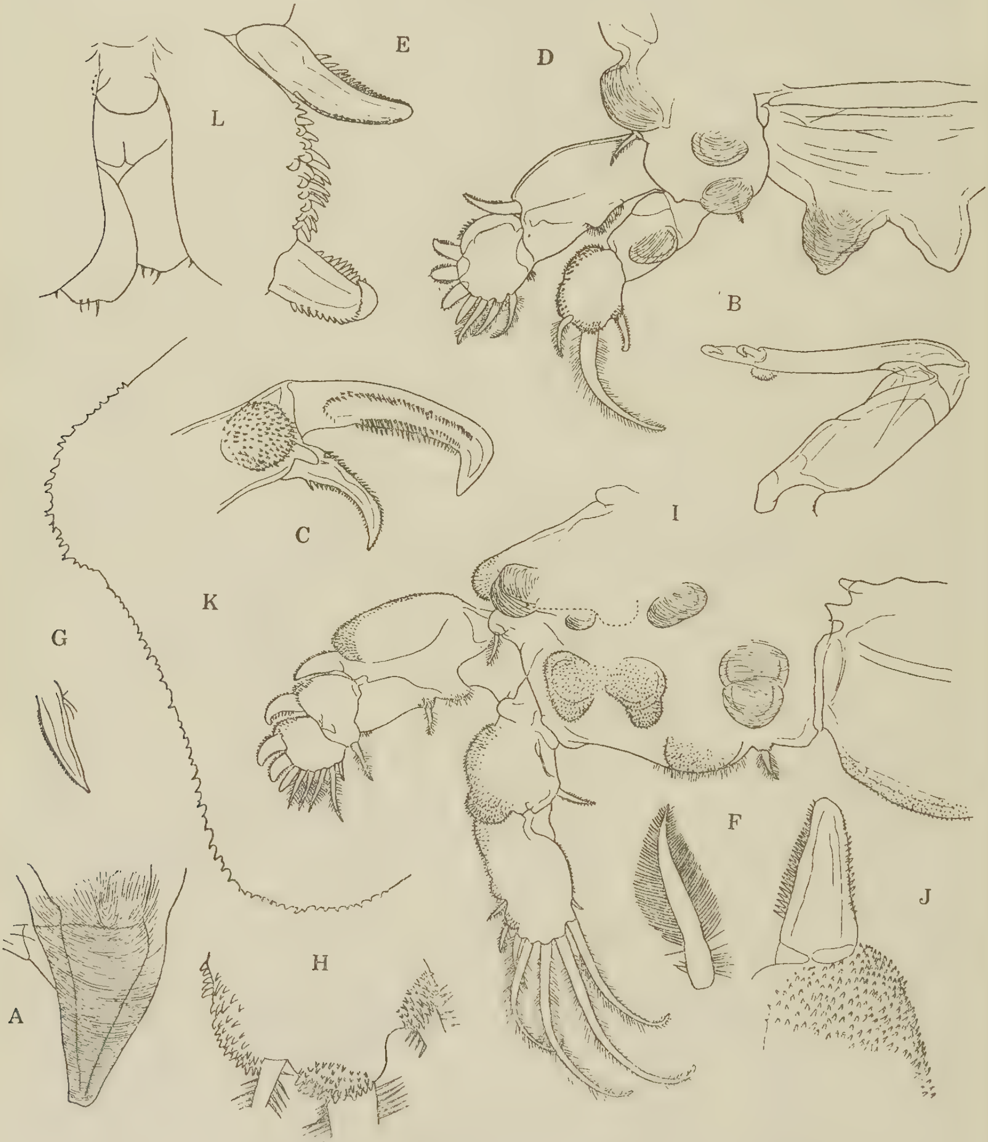


Fig. 2. *Echthrogaleus coleoptratus* Guérin, female. A, adhesive pad in front of the base of 2nd maxilliped, right member; B, 1st maxilliped; C, tip of same, further enlarged; D, 1st thoracic leg with adhesive pads on the sternum; E, spines on outer margin of exopod of same; F, plumose spine taken from apical exopod joint of same; G, another spine of same; H, terminal part of endopod of 1st leg; I, 2nd thoracic leg; J, apical spine on 3rd exopod joint of same; K, postero-lateral border of dorsal plate of 4th thoracic segment; L, 6th thoracic segment, abdomen, and caudal rami. A, C ×83; B, K ×27; D, I ×52; E-H, J ×170; L ×15.

swellings located on either side of the base of elongate oral tube. Each of them a narrow lobe, curved outwards, attenuating to the blunt tip, and carrying at the apex 2 mammiform papillae and near the base a rudimentary accessory lobe tipped with a few spinules. First maxillipeds possess a thickly spinulose, hemispherical knob and a small linguiform lobe close to the base of apical claws. These latter relatively short, rather thick, and fringed with rows of spinules; longer claw bent angularly at the tip. Claw of 2nd maxillipeds stout, bearing a triangular process near the base, besides with basal spine; palm swollen, uneven on its surface owing to the development of ridges and protuberances. Two of these, irregular in shape, locate on inner side and a triangular one on the other side.

Distribution of adhesive pads over the ventral surface are as follows: 1st pair oval, present just behind the bases of 1st antennae, 2nd much smaller, on basal joint of 2nd antennae, 3rd the corrugated triangular lobes, projecting backwards from anterior ends of broad bases of 2nd maxillipeds and lying on either side of mid-line, and 4th similar in outline but smaller, locating on the stenum between first 2 pairs of legs and adjoining together on the mid-line, and 5th represented by ventral thickenings of antero-lateral angles of 2nd thoracic segment.

All 4 pairs of legs biramous. First pair with both rami 2-jointed. Succeeding 2 pairs with 3-jointed exopodite and 2-jointed endopodite. But, articulation line between apical 2 joints of exopodite of 3rd legs partly indistinct. Both rami of 4th legs have all joints fused into one. Number and arrangement of spines on each pair of legs are indicated in the following diagram.*

Legs	Borders	Sternal plate	Protopodite	Exopodite			Endopodite	
				1st joint	2nd joint	3rd joint	1st joint	2nd joint
I	outer		1p	1H	C, 4H			C
	inner		1p	c	c, 3p			1h, 1P, 1p
II	outer	C	C, 1p	C, 1H	C, 1H	C, 3H	C	C, 3p
	inner		1p, c	c, 1p, c	1p	1h, 4p	1h	1h, 4P
III	outer	f	C	C, 1H	C, 1H	C, 2H, 1h	c, C	c, C
	inner		1p, f	c, 1p	c, 1p	5p	1p	2h, 4p
IV	outer		C, 1p	C, 7h			C, 3h	
	inner							

Except those at the tip of endopodite of 2nd legs, all of plumose spines very short and with marginal cilia rather shorter than usual. Other kind of

* Abbreviations used in the diagrams:
C, row of cirri; c, row of cilia; f, membraneous flange; H, longer simple spine; h, shorter simple spine; P, longer plumose spine; p, shorter plumose spine; rh, rudimentary spine; s, solitary seta.

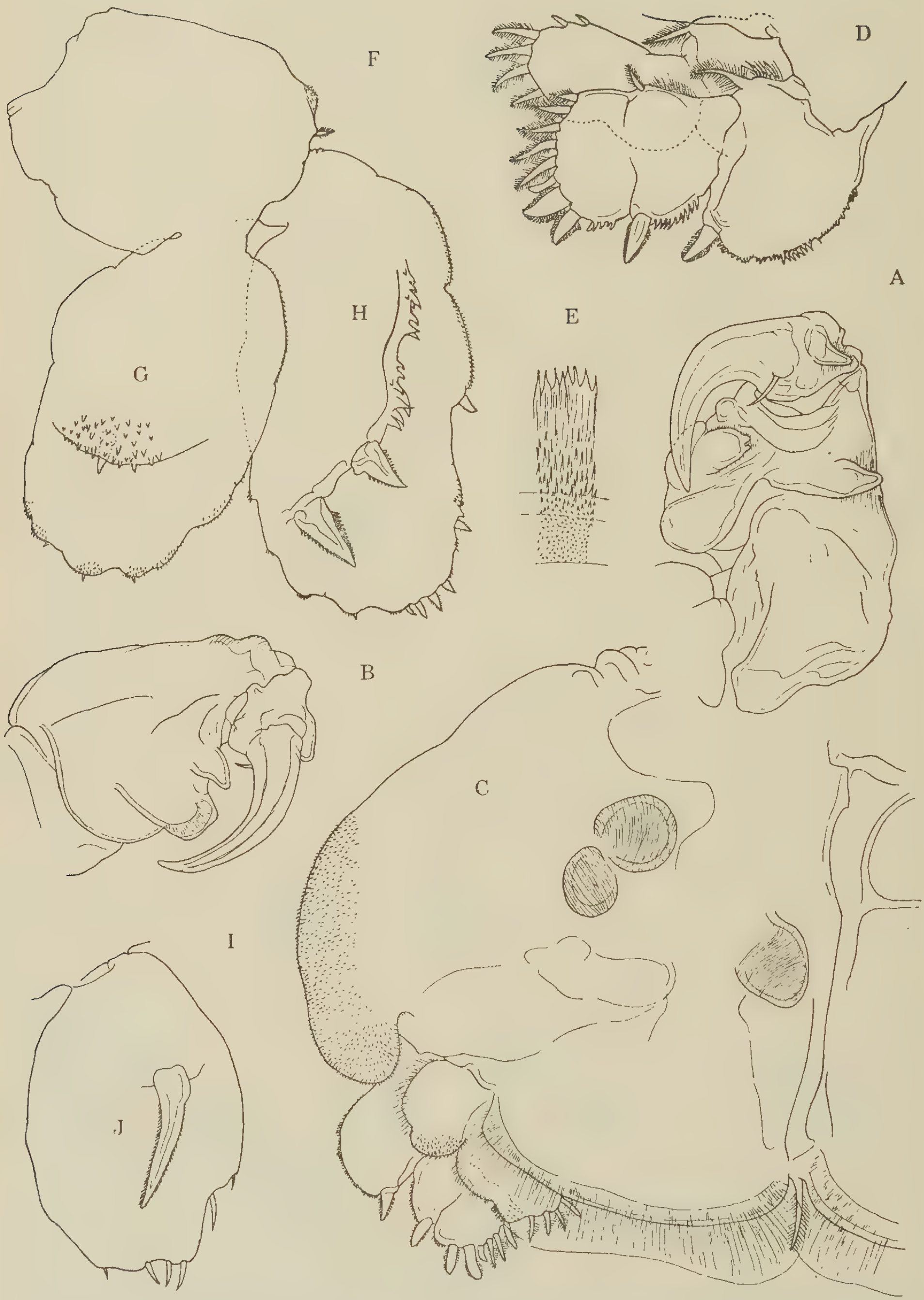


Fig. 3. *Echthrogaleus coleoptratus* GUÉRIN, female. A, 2nd maxilliped, outer surface; B, same, inner surface; C, 3rd thoracic leg; D, 2 rami of same, posterior surface; E, membraneous rim on protopodite of same; F, 4th thoracic leg; G, same, a part of border of endopod, further enlarged; H, same, a part of outer border of exopod; I, caudal ramus; J, spine of same. A, B, F ×31; C ×39; D ×62; E, G, H ×128; I ×7.5; J ×90.

spines stouter, with toothed margins. Those on endopodite of 4th legs much rudimentary. Fifth legs are a pair of acuminate spines placed one on ventral face of each posterior lobe of genital segment. Pads on the surface of thoracic legs are divisible into 2 kinds, one being finely corrugated on the surface with parallel striations and the other covered by fine spinules. They are found principally on the anterior face of legs, namely on the side applied to the host body, and arranged as follows: Corrugated pads 3 on protopodite of 1st legs, 1 on 1st joint of endopodite of the same, 4 on protopodite of 2nd legs, 1 on posterior face of the same, 3 on protopodite of 3rd legs, and spiny pads 4 on protopodite of 2nd legs. Apical endopodite joint of 1st legs, basal joint of 3rd legs are thickly covered by fine spinules over more or less wide areas extending along outer borders. These areas probably play a function of adhesion also.

Caudal rami possess 4 toothed spines which are inserted between 2 much feebler ones on either side.

Male unrepresented in the present collection.

Remarks: YAMAGUTI was right in assigning Japanese specimens to this well-known species. He noticed in them the presence of some differences from what earlier authors had stated. But, it appears to me that this was a result of his comparing them with American specimens described by WILSON (1907). Differences, as I understand them, are found in the outline of the free thoracic segments, in the presence of antero-lateral spines and of fine denticulation along posterior margins on the dorsal plates of the 4th segment, and in the disposition of spines on the thoracic legs. As regards the first and the last points, it is rather astonishing that the description and figures given above are almost in complete agreement with those given by STEENSTRUP and LÜTKEN for European specimens about a hundred years ago (1861) and earlier than WILSON. The latter's statement and figures appear somewhat inexact, at least, about these points. Absence of antero-lateral spines on the dorsal plates of the 4th thoracic segment may be assigned to the failure of the past authors in finding them, since they are completely concealed beneath the plates when viewed from above. Denticles on the posterior margin may have been overlooked by occidental authors, or their presence in Japanese specimens may be attributed to a local variation.

Echthrogaleus denticulatus SMITH, 1874

(Figs. 4–8)

E. denticulatus, SMITH, 1874, Rept. Comm. Fish and Fish. for 1874, p. 282; RATHBUN, 1884, p. 448; WILSON, 1907, p. 369, pl. xx; 1932, p. 428, fig. 268.

Occurrence: Found on the floor of buccal cavity and on the body surface of *Isuropsis glauca* (MÜLLER & HEULE) at Owase market, Mie Pref.; 30 females

and 9 males. On the outside surface of *Prionace glauca* (Linné) at the same place; 2 females.

Distribution: Woods Hole, on *Charcharodon carcharias.*

A remarkable dimorphism is found between the sexes.

Female: Pale brownish yellow or yellowish white, darker on ventral side, genital segment yellow or yellowish brown and darker than carapace. Smaller than foregoing species. Measurements in mm: Body length 7.8, frontal plates, width 2.8, carapace, including posterior lobes 4.1×4.4, same, length on the mid-line 2.8, 2nd and 3rd thoracic segments, length 0.9, 2nd segment, width 2.5, 3rd segment, width 1.3, 4th segment, length on the mid-line and width at the base 2.9×3.7, dorsal plates of same, width 1.9, genital segment, including lateral lobes 3.9×3.7, abdomen 1.0×1.1, egg strings 27.5.

Carapace orbicular, about half as long as body, only slightly wider than long, with surface more or less uneven in anterior region. Frontal plates 2/3 as wide as carapace, somewhat arched anteriorly; free margin more or less undulated, with a broad, shallow, median sinus and fringed by extremely narrow, membraneous rim. Sides of carapace widely round, with a slight notch at about the centre. Posterior margin nearly straight. Lateral areas narrow, 1/3 as broad as central area, from which they are separated by gracefully arcuate longitudinal grooves. Transverse groove across the former is in front of posterior margin of the latter, and more or less incomplete. Posterior lobes with their apices round, curved inwards, and covered by dorsal plates of 4th thoracic segment. Lateral membraneous rims narrow, encircling posterior lobes to extend as far as anterior ends of their inner borders. Similar rims present also on posterior margin of carapace, one at each extreme lateral end covering a short distance. Eyes indistinct.

Second and 3rd thoracic segments completely coalesced together. Dorsal plates of the former lateral, quadrate, directed a little backwards, and concealed beneath posterior lobes of carapace. They are fringed on posterior border with rudimentary membraneous rim. Third segment half as wide as 2nd, with dorsal plates represented by a pair of rudimentary triangular lobes on posterior side. Those plates on 4th segment greatly expanded, oblong, covering nearly 2/3 of genital segment, but not quite meeting on the mid-line. Each of them armed with a short, sharp, laterally directed spine at antero-lateral angle and with minute denticles along posterior margin. Genital segment thickened dorso-ventrally, as long as carapace, but somewhat narrower, with curved, more or less uneven sides and round antero-lateral angles. Posterior lobes occupying more than 1/3 of segment length, with their round apices bending inwards and close to each other on the mid-line. Sixth segment visible from above, represented by shield-like postero-median process of genital segment with which it is

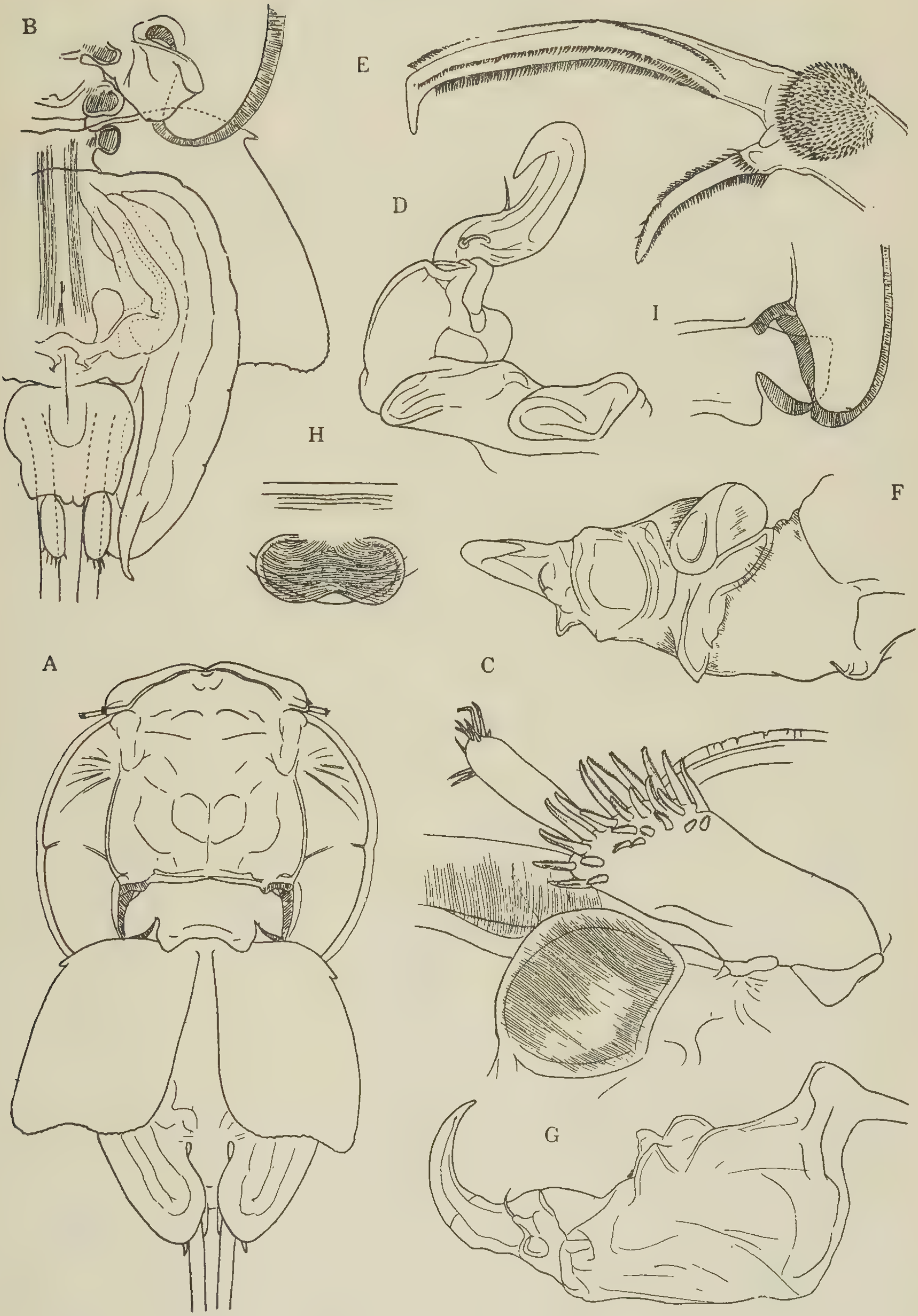


Fig. 4. *Echthrogaleus denticulatus* SMITH, female. A, female, dorsal view; B, same, posterior part of body, ventral view; C, 1st antenna, ventral view; D, 2nd antenna; E, tip of 1st maxilliped; F, 2nd maxilliped, inner surface; G, same, lateral surface; H, adhesive pad just behind the 1st thoracic legs; I, postero-lateral part of carapace and 1st free thoracic segment, dorsal view. A ×10; B, I ×16; C ×83; D-H ×41.

completely fused. Abdomen placed on ventral surface of genital segment as a trapezoid plate. It is as long as wide, wider anteriorly, round at antero-lateral corners, slightly sinuous a little behind the middle of lateral margins, and angular at posterior corners.

First antennae with basal joint narrower than usual, twice as long as apical joint; spines along distal margin of the former fringed with rudimentary hair, while apical setae on the latter simple. Adhesion pads just behind this limb pair relatively small, ovate and with finely corrugated surface. Claw of 2nd antennae stout, with 2 short spines, placed one at the base and the other more distally, 2nd joint short but broad, and basal joint with 2 obovate, proximo-distally arranged adhesion pads. First pair of maxillae missing. Second pair and oral tube associated together as in *coleoptratus*. The former acuminated to the tip, with 2 spinules near the base, and the latter elongate, slender. Longer claw at the top of 1st maxillipeds exceeds twice the length of shorter one and has its tip curved at right angles. Both of them with rows of well-developed, thickly set spinules along borders; spiny, hemispherical bulge at their bases rather large and appended with a small linguiform lobe. Terminal claw of 2nd maxillipeds stout, well curved, reenforced with a conical process as well as a short hair close to the base; basal joint swollen, with 2 bulges in the form of irregularly-shaped, transverse ridges on inner surface. Anterior ends of this limb pair form triangular adhesive pads, on either side of mid-line. Disposition of the pads on under face of carapace as in preceding species. But, those on mid-ventral surface between the bases of first 2 pairs of legs hemispherical, finely corrugated and close to each other.

All pairs of thoracic legs biramous. Both rami 2-jointed in 1st pair, 3-jointed in 2nd, and unjointed in 4th. Exopodite of 3rd pair composed of 3 joints, while endopodite of 2 joints; terminal joint of the latter with a notch on outer border, indicating the site of border between the fused ones. Disposition of spines and other armatures on them are tabulated as in the following:

Legs	Borders	Sternal plate	Protopodite	Exopodite			Endopodite		
				1st joint	2nd joint	3rd joint	1st joint	2nd joint	3rd joint
I	outer		1p	1H	C, 4H			C	
	inner		1h	c	c, 3P			C, 3P	
II	outer	C	C, 1h	C, 1H	C, 1H	C, 3H	c, C	c	c, 1p, C
	inner			1P	1P	1p, 4P	1P	c, 1h, 1P	5P
III	outer	f	C, 1p	C, 1H	C, 1H	C, 3H	c	2c	
	inner		f, 1P	c, 1P	c, 1P	5P	1P	2rh, 4P	
IV	outer		C, 1p	C, 5H			C, 1h		
	inner		C	C			1h		



Fig. 5. *Echthrogaleus denticulatus* SMITH, female. A, 1st thoracic leg; B, plumose spine of same; C, lateral margin of exopod of same; D, 2nd leg; E, 3rd leg; F, 2 rami of same, posterior view; G, 4th leg; H, caudal ramus, ventral view; I, margin of dorsal plate of 4th thoracic segment. A, F ×83; B, C ×170; D, E, H ×52; G ×41; I ×48.

Plumose spines on all the legs relatively longer than in *coleoptratus*, but similar in having rather short marginal hairs. Other spines thickly toothed on margins. On apical joint of exopodite of 1st leg and on basal joint of the same of 3rd, marginal cirri form a row of minute plates by intimate coalescence of several of them. In other joints and in other legs which have marginal spinules, these cover more or less wider area. Outer distal angle of protopodite bears spinules in all legs except 1st where it shows striations on the surface. Spiny area far broader in 3rd legs than in others, and covering also inner distal angle of 4th. Both rami of 4th limbs are divided along their margins into a number of spiny areas, on each of which there is a spine longer than other spinules; exopodite bears 2 indentations on outer margin indicating sites of boundaries of fused joints. First 3 pairs of legs bear 3 corrugated bosses on anterior face on both sides. These are distributed in 1st legs 2 on protopodite and 1 on basal joint of exopodite, but in others all on protopodite. Two of the bosses on 2nd legs much smaller than the rest 1, and this pair of legs with another large 1 on posterior face. Bosses on 3rd legs of about the same size, but 2 of them standing close to each other, the rest isolating. Rudiments of 5th legs are chitinous rods running lengthwise on ventral surface of posterior lobes of genital segment; they accuminate backwards to a point and extend beyond apices of the lobes.

Caudal rami narrow, twice as long as wide, with 6 simple apical spines; outer- and innermost ones smaller than others. Inner margin of the rami bears 3 areas of fine spinules.

Male: Nogagus-form. Pale yellowish white, with light brownish patterns at lateral ends of frontal plates as well as at anterior extremity of carapace on either side of mid-line. Eyes with black pigment. Measurements in mm: Entire length, excluding caudal rami 9.7, carapace, including lateral lobes 4.7×5.4, same, length on the mid-line 3.5, frontal plates, width 3.8, dorsal plates of carapace, length 1.6, 2nd thoracic segment, including lateral lobes 1.4×3.4, same, length on the mid-line 8.2, 3rd segment 0.8×2.3, 4th segment 1.0×1.8, genital segment 2.2×2.5, abdomen, length 1.1, 1st segment 0.5×1.0, 2nd segment 0.5×1.0.

Carapace depressed, suborbicular, wider than long, showing a larger transverse calibre anteriorly rather than posteriorly, and with cephalic area somewhat uneven on the surface. Frontal plates evenly round, broader laterally, narrowing towards the median and interposing a shallow sinus; membraneous rims along free margins rudimentary. Either side of carapace round, with a slight notch about the middle and with broad marginal membranes. Lateral areas narrow, less than 1/3 as broad as central area; posterior lobes acuminating towards the tips and bending inwards. Paired longitudinal grooves on dorsal

face concave inwards, but their anterior ends curved outwards to reach near the bases of antennae. Transverse grooves across lateral areas rather incomplete, placed on the level with central notches on side margins. Posterior border of carapace nearly straight, with a pair of large, opaque, movably articulated, secondary plates on either side. Each plate longer than wide, round at the apex,

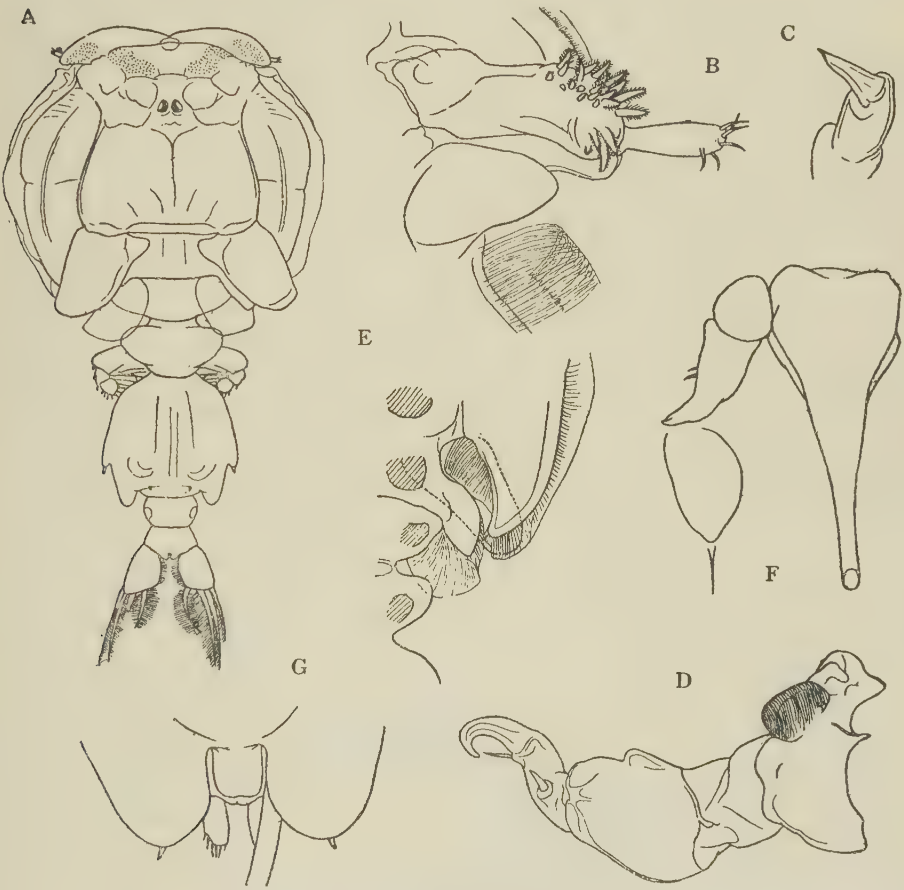


Fig. 6. *Echthrogaleus denticulatus* SMITH, male and female. A-E, male; A, dorsal view; B, 1st antenna; C, 2nd maxilla; D, 2nd antenna; E, postero-lateral part of carapace and free thoracic segments, ventral view; F-G, female; F, oral tube, 1st maxilla and adhesive pad; G, 6th thoracic segment. A ×7.3; B, D ×41; C ×83; E ×10; F ×52; G ×15.

with a short, linguiform, inner basal lobe, and extending postero-externally to overlap lateral lobe of following segment. Eyes placed at anterior 1/3 of carapace.

Second thoracic segment free from carapace, with lateral lobes more or less acuminating towards the tips and directing to the same direction as dorsal plates of carapace. They bear a broad, crescent, transparent, posterior mem-



Fig. 7. *Echthrogaleus denticulatus* SMITH, male. A, 1st maxilliped; B, tip of same, further enlarged; C, 2nd maxilliped; D, 1st thoracic leg; E, protopodite of same, posterior view; F, 2nd leg; G, exopodite of same, posterior view; H, outer border of 2nd joint of same; I, postero-lateral part of genital segment. A ×15; B ×62; C ×20; D-G ×39; H ×117; I ×31.

brane on either side. Succeeding 2 segments round on sides, without lateral lobes and marginal membrane; 4th segment narrower than 3rd, with which it is connected by a sort of short neck. Genital segment a little wider than long, widest on the level through 5th leg rudiments which are present at its posterior third as paired, small, triangular lobes of lateral sides. The segment narrows from these both in front and behind. Two sides, forming obtuse angles anteriorly, converge abruptly towards narrow articulation border with preceding segment. Posterior corners extend backwards as paired lobes, which are larger than 5th leg lobes and narrow towards blunt apices. Dorsal face of the segment bears a pair of dorsal spinules close to posterior border, one on each side of median line. Abdomen composed of 2 segments subsimilar in size; 1st segment with round sides, 2nd pentagonal, with diverging sides and V-shaped posterior border.

First antennae as in female, with basal joints entirely covered by frontal plates. Adhesive pads just behind their bases obovate. Apical joint of 2nd antennae bears 2 spines; proximal spine stouter than in female ending in a sharp point. Second joint with a low boss on outer side and basal joint with a small, corrugated adhesion pad. Second maxillae placed on either side of mouth tube, indistinctly 3-jointed; basal joint round, 2nd cylindrical, surmounted with acuminated 3rd. First maxillipeds with a narrow dactyliform accessory lobe at the base and distal joint bearing 3 apical spines of unequal lengths. Longest spine about twice as long as the middle one, bent at a right angle at the tip; both with finely serrated rims along their lengths. Shortest spine 1/5 the longest, dactyliform, issued from outer surface of the joint between the bases of other spines, with rows of short hairs along 2 borders and a longer solitary one close to the base. Palm of 2nd maxillipeds inflated on inner side and with 2, large and small, corrugated protuberances; terminal claw curving only at the tip and with a spine on inner side.

Four pairs of legs entirely different from those of female in their constitution, and with both rami composed of 2 joints. Endopodite of 1st legs scarcely attaining the end of 1st joint of exopodite. Arrangement and numbers of spines on the legs may be clarified by the table inserted at the top of the next page.

Plumose spines on all pairs far longer than in female and thickly fringed with well-developed hairs. Non-plumose ones much shorter, with finely serrated borders. Cirri on outer border of joints, when present, arranged in 2 or 3 rows, but covering much wider area in apical exopodite joint of 1st legs. Marginal hairs along outer border of endopodite joints of 3rd legs also occupying broader areas than in other legs. First legs have 3 corrugated bosses on anterior face; these are placed one at each distal angle of protopodite and another on basal joint of endopodite. In addition to these, protopodite with a spinulose protuberance

Legs	Borders	Sternal plate	Protopodite	Exopodite		Endopodite	
				1st joint	2nd joint	1st joint	2nd joint
I	outer inner		2p C	1H c	C, 4H 3P		c 3P
II	outer inner	f	C, 1p 1P, f	f, C, 1H c, 1P	C, 4H c, 6P	c 1P	c c, 8P
III	outer inner	f	C 1P, f, 1rh	2C, 1H 1P	C, 4H 5P	c 1P	c c, 6P
IV	outer inner		C, 1p C	2C, 1H c, 1P	C, 4H 5P	c 1P	C, c c, 5P

on inner border on posterior face. Same joint of succeeding legs with a similar protuberance at outer distal angle on anterior face, and brimmed with broad membraneous rim along inner border in 2nd and 3rd legs. Marginal rim very narrow in 4th legs and absent in 1st. Fifth leg rudiments bear a stout apical spine and 2 feebler plumose ones on inner border. Remnants of 6th legs are processes of irregular shape, discovered beneath paired lobes on posterior border of genital segment and entirely concealed from above. They have a plumose spine besides a simple apical one.

Caudal rami rather large, their lengths including apical spines equal to that of genital segment. Each of them nearly triangular, bearing 4 long terminal spines and a similar but very minute one at inner distal angle on dorsal face, and with ciliated inner border.

Remarks: This is the first record of the male of *denticulatus*. The female specimens in the present collection exhibit some differences in the constitution of the swimming legs from the one described by Wilson. The endopodites of the 2nd legs are 3-jointed in my specimens, while they are 2-jointed in Wilson's, and the 3 joints composing the endopodites of the 4th legs in the latter are entirely coalesced in the former. Besides, the number and arrangement of spines on the legs are more or less different between the 2 lots of specimens. Another difference existing between them is that the dorsal plates of the 4th thoracic segment of the present females have denticles only along posterior borders, lacking these on the inner borders unlike the type specimen. In spite of these points of disagreement, I dare assign my specimens to *denticulatus* from the following considerations: American species was erected by Smith upon a single female and this was the sole specimen which Wilson could examine. So, it is doubtful to me if they could study the appendages removed from the body. As the appendages are crowded together on the ventral surface of body overlapping upon one another, studying them in situ is liable to lead one to an erroneous conclusion as regards the disposition of their spines as well

as the number of composing joints. Otherwise, the appendages of this specimen might have been somewhat damaged.

It is not uncommon in the genera of Pandaridae that one and the same species can be found both from the Atlantic and from the Pacific. A remote distance between the localities cannot justify the separation of the 2 lots of specimens as distinct species.



Fig. 8. *Echthrogaleus denticulatus* SMITH, male. A, 3rd thoracic leg; B, outer margin of 1st exopod joint of same; C, 4th leg; D, exopod of same, posterior view; E, caudal ramus, dorsal view. A, C, D ×39; B ×117; E ×20.

E. neo-zealanica (=*Dinematura neo-zealanica* THOMSON) is another species which has the 5th leg rudiments of the female extending beyond the posterior lobes of genital segment as in the present species. The two, however, are entirely different in the characters of the male, especially in that of the genital segment, besides in other somewhat minor points.

Genus *Dinematura* LATREILLE, 1892

Dinematura latifolia STEENSTRUP & LÜTKEN, 1861

(Figs. 9 & 10)

Dinematura latifolia, STEENSTRUP & LÜTKEN, 1861, Vidensk. Selsk. Skrift., math.-naturh., v, p. 378, pl. viii, fig. 16; BASSETT-SMITH, 1899, p. 463; BRIAN, 1906, p. 52; WILSON, 1907, p. 383, pl. xxiv–xxv; 1923, p. 6, pl. i, figs. 6–10; 1932, p. 432, fig. 271; 1935, p. 778; YAMAGUTI, 1936, p. 9, figs. 50–61.

Occurrence: On the ventral surface of *Isuropsis glauca* (MÜLLER & HEULE) taken off Irôzaki Point, Izu, Sizuoka Pref., 3 females, no male.

Distribution: The species has an extraordinarily wide range of distribution and is parasitic on a number of species of shark. N. Atlantic (STEENSTRUP & LÜTKEN), Mediterranean (HELLER, CARUS), Adriatic (VALLE), Elba (BRIAN), S. Africa (WILSON), English caost (WILSON), Atlantic coast of United States (RATHBUN, WILSON), Messina (WILSON), Monterey Bay (WILSON), and Japan (YAMAGUTI). On *Lamna cornubica, Carcharodon carcharias, Isurus punctatus,* and *Isuropsis glauca.*

As the species was repeatedly described (STEENSTRUP & LÜTKEN 1861, WILSON 1907, YAMAGUTI 1936), I may give here only a short description on the most important characteristics.

Female: Body brownish, with dark brown pigment spots on dorsal surface, darker on central area of carapace and of genital segment. Measurements in mm: Body length 14.5, carapace, length on the mid-line 4.8, same, including posterior lobes 6.5×7.6, 2nd thoracic segment 0.8×5.4, 3rd segment 0.8×3.6, 4th segment, length on the mid-line 1.8, same, including dorsal plates 3.4×6.5, genital segment, length on the mid-line 3.6, same including posterior lobes 5.4×4.6, 6th thoracic segment 2.7×1.7, abdomen 1.1×1.5, egg strings 53.4.

Carapace orbicular, longer than wide including posterior lobes, and less than half the body length. Frontal plates broader and more or less angular at either lateral end, narrowing towards the median, with rudimentary marginal rims. Central area with more or less uneven surface, and about twice as wide as lateral areas, which are semi-circular, and has moderately broad marginal membrane. Posterior lobes obovate, attaining hind margin of 3rd thoracic segment. Hind margin of carapace insensibly arched forwards, with either lateral end produced in a small, triangular process, and with a narrow rim along entire width. Paired longitudinal grooves parallel and nearly straight. Eyes indistinct.

Second thoracic segment short but wide. Lateral lobes extending postero-externally, their apical parts concealed beneath posterior lobes of carapace, and with a very broad lunular membrane along hind margin on either side. Third segment with lateral lobes shorter, covered by paired membrane of preceding

segment, and produced posteriorly on either side of a short, narrow neck of following segment into a pair of small, triangular processes. Dorsal plates of 4th segment expand laterally in broad, oval lobes, which, combined together, attain the width of carapace. They elongate posteriorly in triangular lobes covering anterior third of following segment and inserting a rather deep median sinus between each other. Genital segment about as long as and more than half as wide as carapace, with slightly convex sides and divided posteriorly in a pair of oval lobes. Dorsal plates are narrower and shorter than the segment, with which

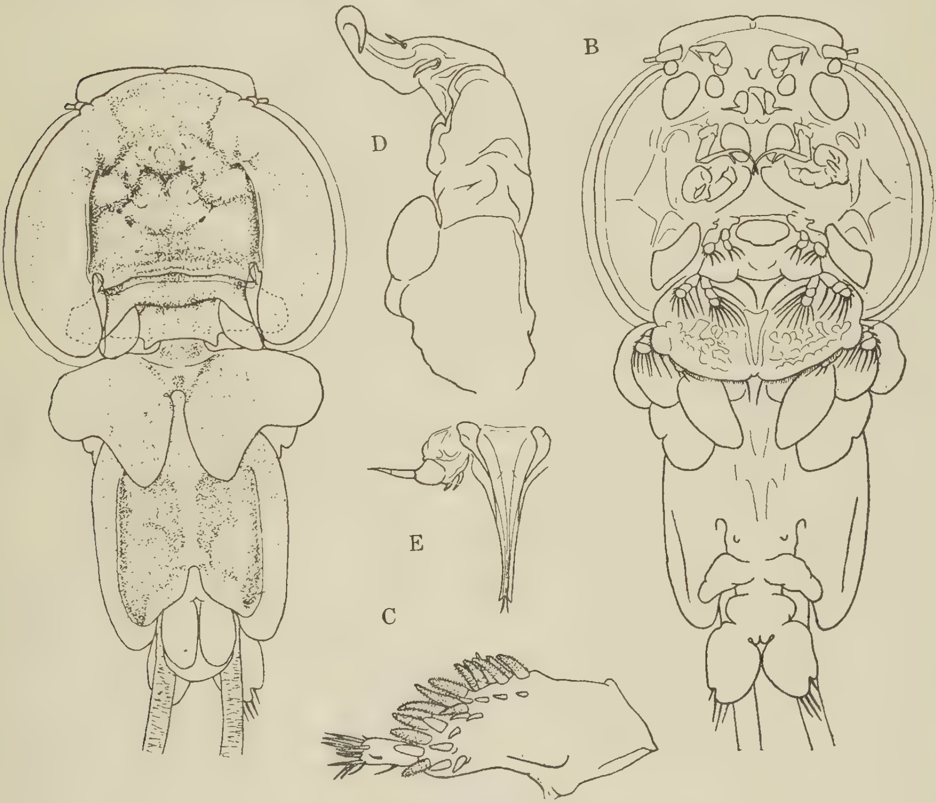


Fig. 9. *Dinematura latifolia* STEENSTRUP & LÜTKEN, female. A, female, dorsal view; B, same, ventral view; C, 1st antenna, ventral view; D, 2nd antenna; E, maxilla with mouth tube. A ×5.5; B ×6.1; C, ×41; D ×27; E ×21.

they are coalesced except in narrow area around the triangular, postero-median sinus separating them from each other. Sixth segment short, cylindrical, concealed beneath genital segment, but prolonged dorsally in a spatulate median plate. The plate, filling up posterior sinus of genital segment extends over abdomen, and is covered again from above by a pair of obovate dorsal plates, which are narrower and shorter than it and separated from each other by a narrow, deep, median slit. Abdomen small, cordiform, and entirely invisible from dorsal side.

Four pairs of adhesion pads and a single median one are present on ventral surface of carapace. First 2 pairs just behind the bases of 1st antennae, arranged on either side one behind the other; anterior pair much smaller than posterior one. Third pair just inside the bases of 1st maxillipeds and on either side of mid-line. Fourth pair represented by broad, thickened areas along anterior edges of lateral lobes of 2nd thoracic segment. Unpaired median one situated just behind the bases of 1st legs.

Apical joint of anterior antennae short, a quarter as long as basal joint; spines on free margin of the latter short and stumpy, surrounded on all sides with fine spinules. Claws of posterior antennae strongly curved, bearing 2 spines as usual; basal joint with an oval, flattened adhesive pad. Mouth tube slender, elongate conical. First maxillae missing. Second maxillae close to either side of mouth tube and consisting of round base bearing short spines and knob-like 2nd joint from which 2 slender, cylindrical joints extend outwards. First maxillipeds with 2 terminal claws unequal in lengths and curled at their tips. Longer claw armed along its length with spiral rows of small plates formed by union of fine cirri; shorter one merely 1/3 as long as the other, with sharp spinules arranged in longitudinal rows. Between 2 claws and closer to the base of longer one, there is a small papilla bearing a tuft of long, stiff setae. Palm of 2nd maxillipeds stout, nodose, with 2 round and a conical swellings, arranged proximo-distally, on inner side and an oval, much larger one on outer side. Terminal claw relatively small, flattened, bearing a spine on inner side, its tip closing against 2 round nodules on the summit of outer swelling of palm.

Four pairs of thoracic legs biramous. Both rami of first 3 pairs fringed with plumose spines and composed of 3 joints except in 1st where these are 2-jointed. Fourth pair fleshy, thicker than, and different in structure from others; protopodite expanded both internally and externally, and 2 rami without plumose spines, but with a number of scattered spinules along their margins. Arrangement of spines and other armatures on them as shown in the following diagram:

Legs	Borders	Sternal plate	Protopodite	Exopodite			Endopodite		
				1st joint	2nd joint	3rd joint	1st joint	2nd joint	3rd joint
I	outer inner		1p 1p	1H c	C, 4H 3P		c	c 3P	
II	outer inner	f	1rh 1P, c	f, 1H c, 1P	C, 1H c, 1P	C, 3H c, 5P	c 1P	c c, 2P	c c, 6P
III	outer inner	f	c 1P, f	C, 1H c, 1P	C, 1H c, 1P	C, 3H c, 5P	c	c c, 2P	c c, 4P
IV	outer inner			2h 3h					

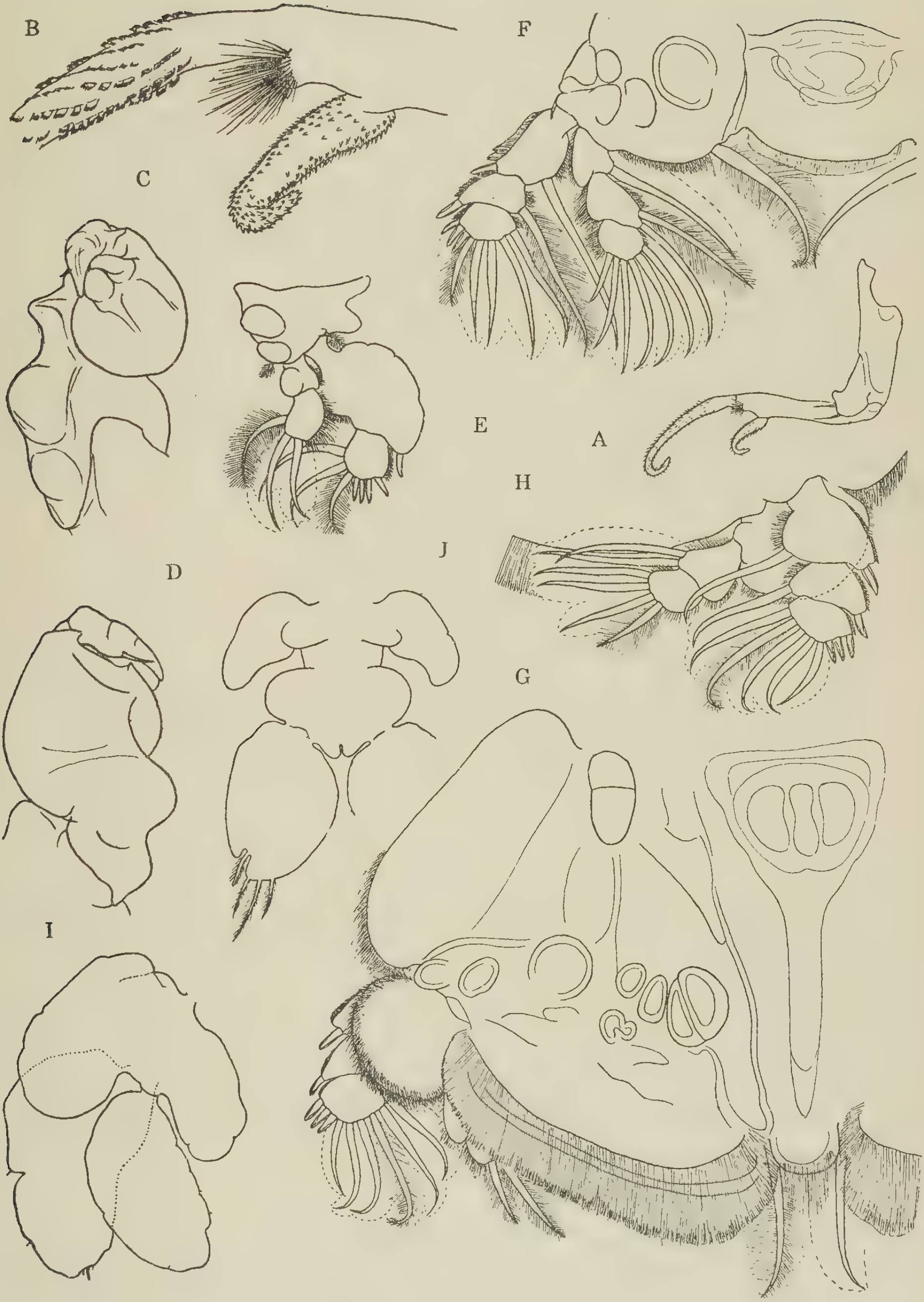


Fig. 10. *Dinematura latifolia* STEENSTRUP & LÜTKEN. A, 1st maxilliped; B, same, basal part of apical spines; C, 2nd maxilliped, posterior face; D, same, anterior face; E, 1st thoracic leg; F, 2nd leg; G, 3rd leg; H, same, posterior face; I, 4th leg; J, 6th thoracic legs, abdomen and caudal rami, ventral view. A ×4.4; B-D ×10.4; E, F ×14; G ×41.

Simple spines on the legs with fine cirri along 2 borders. Anterior face of 1st legs with 2 adhesion pads on inner border of protopodite and a single one on basal joint of exopodite. Succeeding 2 pairs also with a number of pads on the same face of protopodite. Fifth leg rudiments undiscovered. Sixth legs present on either side of corresponding segment and concealed beneath genital one. Each of them consists of a narrow, foliaceous lamina which bears a smaller, lunular, secondary one on posterior side close to its base.

Caudal rami obovate, foliaceous, terminating in 4 short, plumose spines.

Remarks: Yamaguti (1936) has pointed out that Japanese specimens are somewhat different from those reported by Wilson (1907) in the shape of the 3rd thoracic segment, in the arrangement of adhesion pads and in the number of spines on the thoracic legs. They are, however, in strict accord with Steenstrup and Lütken's original description and figure, at least, in the first 2 points, though no detailed information was given as regards the third point.

Genus *Pandarus* Leach, 1816

Pandarus satyrus Dana, 1852

(Figs. 11–17)

Pandarus satyrus, Dana, 1852, U.S. Explor. Exped., xiii, p. 1367, pl. xcv, fig. 1; Brady, 1883, p. 134; Yamaguti, 1936, pt. 3, p. 5, pls. iii–iv, figs. 36–41.
P. cranchii, Steenstrup & Lütken, 1861, p. 390, pl. xi. fig. 22; Rathbun, 1886, p. 317, pl. v, fig. 1.
P. zygaenae, Brady, 1883, p. 134, pl. lv, fig. 3.

Occurrence: On the body surface of *Sphyrna zygaena* (Linné) examined at Hamazima market, Mie Pref.; 18 adult females with egg strings, 16 adult but somewhat premature females, 14 young females, 12 adult males, and 5 males of a copepodid stage. On the body surface of *Isuropsis glauca* (Müller & Heule) taken at the same locality; 2 adult females. On the body surface of the same taken at Owase market, Mie Pref.; 16 adult females with egg strings, 6 adult females before oviposition, 1 young female, 9 adult males and 11 young males of copepodid stages.

Distribution: Hawaii (Wilson), Kermadec Isl., Cape Verde Isl. (Brady), Gulf of Mexico (Brady), Japan (Yamaguti). On *Prionace glauca*, *Carcharias brachurus*, *Zygaena malleus*, *Sphyrna zygaena* (new host) and *Isuropsis glauca* (new host).

The present species was most exactly described by Yamaguti (1936), but the male form and the younger stages of the both sexes have not been recorded up to now. The following descriptions are based on the specimens taken from a single individual of *Sphyrna zygaena*, unless otherwise indicated.



Fig. 11. *Pandarus satyrus* DANA. A, female, parasitic on *Sphyrna zygaena*; B, same female, dorsal view, further enlarged; C, male parasitic on the same host, dorsal view; D, female, ventral view; E, male, ventral view; F, male, postero-lateral part of carapace, with free segments, dorsal view; G, male, postero-lateral part of genital segment, ventral view. A ×4.4; B-D ×10.4; E, F ×14; G ×41.

Female: Variable in coloration. In *Sphyrna* specimens, color pale yellowish brown, with dark brown blotches near anterior margin of carapace and on either side of central area (Fig. 11, B). Similar blotches are also found on frontal plates, on dorsal plates and on median one of 6th thoracic segment, but their margins are left yellowish. Genital segment pale brown. In general, depth of colors and extent of colored areas are rather variable. Younger females are lighter than the older ones, and even among the adult ones, those without egg tubes are nearly entirely devoid of brown blotches. Female on *Isuropsis* have darker blotches and are wider in areas. Some of them are almost black, bearing a light spot on either side of mid-line on the ocular region and uncolored narrow areas on the margins and angles of segments as well as on anterior part of genital segment (Fig. 12, A).

Proportion of body parts also variable. Measurements taken from 2 extreme cases, which are found on 2 different hosts are as follows: Female from *Sphyrna zygaena* (Fig. 11, B): Body length 8.7, carapace, length on the mid-line 3.7, same, including lateral lobes 4.4×4.3, frontal plates, width 3.2, 2nd thoracic segment, length on the mid-line and width at the base 0.3×3.3, same, including dorsal plates 3.2×3.9, 3rd segment, length on the mid-line 0.5, same, including dorsal plates 0.9×1.7, 4th segment, length on the mid-line 1.1, same, including dorsal plates 1.5×2.5, genital segment, length on the mid-line 2.7, same, including posterior processes 3.2×2.9, 6th segment 1.3×1.2, abdomen 1.0×1.8, egg strings 9.3. Female from *Isuropsis glauca* (Fig. 12, A): Body length 10.0, carapace, length on the mid-line 4.1, same, including lateral lobes 4.7×5.0, width of frontal plates 3.7, 2nd thoracic segment, length on the mid-line and width at the base 0.3×3.8, same, including dorsal plates 2.3×4.8, 3rd segment, length on the mid-line 0.8, same, including dorsal plates 1.3×2.8, 4th segment, length on the mid-line 1.1, same, including dorsal plates 1.5×3.6, genital segment, length on the mid-line 2.4, same, including posterior processes 3.1×3.4, 6th segment 2.2×1.8.

Fine spinules are scattered over upper surface of carapace and dorsal plates of thoracic segments. Posterior extremity of genital segment with somewhat stronger spine.

Carapace as long as wide, wedge-shaped narrowing anteriorly. It is strongly convex above, not showing any suture on its surface. Anterior margin arched forwards. Lateral margins nearly straight, curving and elongating at postero-lateral angles in triangular lobes. Posterior margin somewhat convex backwards in central region, with a row of spines usually turned upwards. Frontal plates broader laterally, narrowing towards the median, and with evenly curved margins. Eyes indistinct.

Second thoracic segment short in central region with nearly straight

posterior border, but developing a pair of long, obovate, dorso-lateral plates extending backwards. Succeeding 2 segments have each a pair of semi-circular dorsal plates. Those of right and left largely fused being separated by a shallow posterior sinus. Plates of 3rd segment far smaller than and overlapping those of 4th, which, in turn, cover anterior half of genital segment. Genital segment large, longer than wide, thickened dorso-ventrally. It is narrowed at posterior



Fig. 12. *Pandarus satyrus* DANA. A, another female, parasitic on *Isuropsis glauca*, dorsal view; B-H, female (same as that shown in Fig. 11, B); B, 1st antenna; C, 2nd antenna; D, same, anterior view; E, oral tube with maxillae; F, 1st maxilliped of right; G, tip of same of left; H, 2nd maxilliped of right; I, J, male; I, 2nd antenna; J, 2nd maxilliped. A ×5.8; B-F, H-J ×31; G ×61.

end and produced backwards into a pair of short processes, between which a concave, semi-circular posterior border is inserted. When viewed from ventral side after removing thoracic legs, anterior end of the segment is seen to be produced on either side of its narrow median neck into oval lobes extending to the bases of dorsal plates of 4th segment. Median dorsal plate of 6th segment is

inserted in posterior excavation of genital segment, longer than wide, spatulate, with narrow base and round posterior border. Abdomen concealed beneath this plate and tightly coalesced with its own quadrangular ventral plate. The latter wider than long, retreating from posterior margin of 6th segment, and divided into 2 segments; anterior segment much shorter, with its frontal end submerged in ventral surface of genital segment.

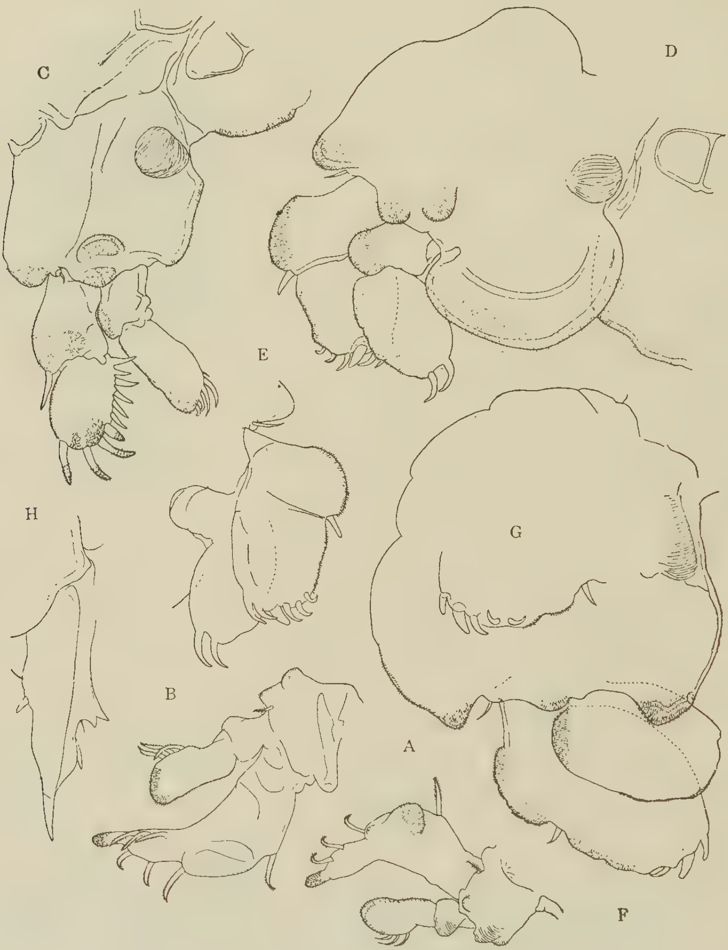


Fig. 13. *Pandarus satyrus* Dana, female. A, 1st thoracic leg; B, same, posterior view; C, 2nd leg; D, 3rd leg; E, same, posterior view; F, 4th leg; G, exopodite of same, posterior view; H, caudal ramus. A, C-G ×31; B ×38; H ×20.

Proximal joint of 1st antennae slender, with anterior rows of non-plumose spines. Claw of 2nd antennae well-curved and provided with 2 accessory spines as usual, 2nd joint inflated, with a conspicuous swelling on outer side, and basal joint with an oval adhesive pad close to its base. Mouth tube elongate and slender. Anterior maxillae wanting. Posterior maxillae close to either side of

the base of mouth tube, elongate foliaceous, terminating in lanceolate apices. First pair of maxillipeds with 2 terminal claws of unequal lengths and a very short third one near their bases on posterior side. Longer claw twice as long as shorter one, both bearing longitudinal rows of fine spinules; third one dactyliform and with tufts of long hairs on 2 sides. Second pair of maxillipeds massive and nodose, with their bases continuing to a pair of swollen, triangular areas of sternum, within which strong musculatures are developed. Palm has 2 round knobs and an elongate, distally bifid plate on the region against which the tip of claw usually acts. The parasite sticks so firmly to the host body inserting the claw into the hard skin that this in almost all cases broken from the very base, when it is detached with force. Adhesive pads are disposed on ventral surface as in the following: 1st pair just behind the bases of 1st antennae, 2nd pair just inside the 1st pair and close to the bases of 2nd antennae, 3rd pair at anterior ends of broad bases of 2nd maxillipeds, 4th pair at antero-lateral angles of lateral plates of 2nd thoracic segment, and median 5th locating on mid-line behind the bases of 1st pair of thoracic legs.

All 4 pairs of thoracic legs biramous. Endopodite of 1st legs smaller than exopodite, both composed of indistinctly separated 2 joints. Two rami distinctly 2-jointed in succeeding 2 legs, but unjointed in the last. Swimming spines all short, curved and non-plumose, but those on both rami of 1st legs with rudimentary fringing hairs. Apical 4 spines on exopodite of 2nd legs beset with similar, minute hairs around their apical halves. Arrangement and number of them on each of the rami are tabulated as in the following:

Legs	Borders	Sternal plate	Protopodite	Exopodite		Endopodite	
				1st joint	2nd joint	1st joint	2nd joint
I	outer inner		1p C, 1p	1h, C, 3h 3h, C		C	C 3h
II	outer inner	C	C, 1rh C	C, 1H 6H	C, 4H	C	C 1rh, 4h
III	outer inner	C	C, 1h C	C, 1H	C, 3h, 1H 2h	C	C 2H
IV	outer inner		C, 1rh	C, 1h, C, 2h 3H		C	

First legs have 2 small ciliated bosses on anterior face of protopodite, one between the bases of 2 rami, the other at inner distal angle, and another corrugated one on distal border close to the latter. First joint of endopodite with a corrugated boss. Spatulate apex as well as inner margin of this ramus finely ciliated. Other ramus ciliated around its dactyliform tip, on oblong area along outer margin about the middle of anterior face, and on a prominent boss on the

opposite face. Succeeding 2 legs have corrugated bosses on protopodite close to the junction with the median sternal plate and 3 ciliated ones near the bases of 2 rami. They are similary ciliated along inner border of protopodite, on free border of sternal plate, and on outer margins of both rami. Protopodite of 3rd legs expanded forming a semi-circular plate on inner margin. That of last legs also extended, more or less corrugated close to the base of inner border and with 3 ciliated low protuberances on distal margin; both rami also with cilia on outer borders.

Caudal rami diverging from each other. Each ramus is keeled along its length and forms on either side of the keel 2 narrow wings, the inner one being parallel with ventral surface of abdomen and the other standing upwards. Two wings attenuate towards their common apex, terminating in a strong spine and have undulated margins, which bear 2 triangular processes and a spine on the outside and a single spine on the inside, besides carrying a few setae.

Male: Depressed, *Nogagus*-form, fundamentally differing from female in general constitution. Semi-transparent, lacking any pigment patterns such that found in female, uniformly tinged with pale brownish color, sometimes almost colorless. Measurements in mm taken from a male on *Sphyrna zygaena*: Body length 7.3, carapace, length on the mid-line 2.6, same, including lateral lobes 3.7×4.0, frontal plates, width 3.1, 2nd thoracic segment, length on the mid-line 0.6, same, including lateral lobes 1.2×3.2, 3rd segment 0.6×1.6, 4th segment 0.7×1.3, genital segment 1.8×1.8, abdomen, length 0.8, 1st segment of same 0.4×0.6, 2nd segment 0.4×0.7.

Carapace round, a little wider than long, including posterior lobes. Anterior margin slightly arched, framed with frontal plates resembling those of female. The plates extend freely laterally for a short distance as blunt lobes, their combined length being 3/4 the width of carapace. Lateral areas 1/5 as broad as subquadrate central area. Two sides evenly round, but with a notch at about the middle and another one far anteriorly; membraneous rims relatively broad. Posterior lobes much narrowed towards their apices and curved inwards. They reach the level of the middle of 4th thoracic segment; their concave inner borders fringed with very broad lunular rims. Posterior border of carapace slightly arched forwards, with a small irregular bulge and a broad, transparent, lunular membrane on either lateral ends. Longitudinal surface grooves somewhat convergent anteriorly, but curved outwards near their extreme ends to reach anterior notches on lateral margins. Eyes indistinct.

Second thoracic segment a quarter as long as carapace on the mid-line, less than half as wide at the anterior level and provided with well-developed, postero-laterally directed lateral plates. These, attaining the level with the end of following segment, terminate in triangular apices, and have each a broad,

oval, transparent membrane on posterior side. Third segment more than twice wider than long, as long as 2nd segment, transversely obovate having well-round sides. Fourth segment resembling 3rd in outline, but narrower, and produced both in front and behind into short necks by which it is connected with adjoining segments. Genital segment subquadrate, somewhat narrower than half the width of carapace, and as long as its own width. It is evenly round at antero-

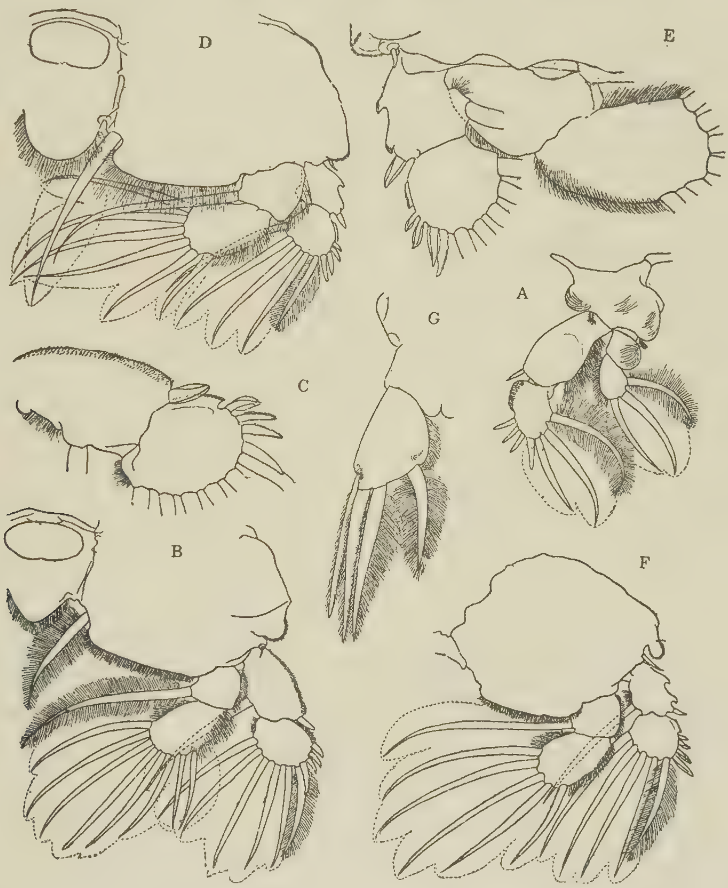


Fig. 14. *Pandarus satyrus* DANA, male. A, 1st thoracic leg; B, 2nd leg; C, exopodite of same; D, 3rd leg; E, both rami of same, posterior view; F, 4th leg; G, caudal ramus, ventral view. A, B, D, F ×31; C, E ×62; G ×20.

lateral angles, bearing a pair of small triangular lobes, one on each side behind the centre, and produced posteriorly into another pair of similar, but larger ones. Each of anterior lobes, which ends in a short, simple spines associated with 2 plumose ones on inner border, represents remnant of 5th leg. Sixth legs are a pair of oblique ventral ridges concealed beneath posterior lobes and tipped by a simple and a plumose spines. Abdomen a little shorter than half the length of

genital segment and composed of 2 narrow, subequal segments. Anterior segment with round sides and straight articulation borders, while posterior segment with 2 sides slightly diverging backwards and hind margin forming a flattened V.

Cephalic appendages, 1st maxillipeds and arrangement of adhesive pads as in other sex. Second maxillipeds have a distinct, more or less flattened claw, tip of which acts against 2 round knobs on the palm.

Four pairs of thoracic legs quite different from those of female, with well-developed plumose spines. All of them have 2 rami composed of 2 joints. Endopodite of 1st legs much smaller than exopodite. Disposition of spines and other armatures as indicated in the following table:

Legs	Borders	Sternal plate	Protopodite	Exopodite		Endopodite	
				1st joint	2nd joint	1st joint	2nd joint
I	outer inner		1p 1p	1H c	C, 4H 3P		c 3P
II	outer inner	c	C, 1rh 1P, c	C, 1H c, 1P	C, 4H c, 6P	c 1P	c c, 8P
III	outer inner	c	C, 1rh 1P, c	2C, 1H c, 1P	C, 4H 5P	c 1P	c c, 6P
IV	outer inner		1s, C, 1rh c	2C, 1h c, 1P	C, 2h, 2H 5P	c 1P	c c, 5P

Most of simple spines on legs with 2 narrow rims, and sometimes finely serrated on their margins. First legs with 3 corrugated tubercles, arranged one respectively at outer and inner distal angles of protopodite and another on inner side of 1st joint of endopodite. Apical joint of exopodite covered with minute cirri on a narrow area along outer margin. Two exopodite joints of succeeding legs also with cirri on the same margin. On apical joints, these form a narrow, thin, finely serrated plate by welding of their bases. On basal joint of last 2 legs, these are amalgamated together in 2, short, hook-like processes, but are separated in 2nd legs. Outer distal angle of protopodite of 2nd and 3rd legs with a low, round, ciliated boss, which in the last develops into dactyliform, more prominent process.

Caudal rami triangular, provided with 4 strong, terminal, plumose spines; 3 of these crowded together at outer-distal angle, while the rest isolated, locating at inner angle. Each ramus bears, in addition to these, 2 minute plumose spines, one at outer corner on ventral surface and the other at inner corner on dorsal surface; inner border of the ramus ciliated.

Younger females: Successive stages of development of young females are

indicated in Figs. 15 and 17. All of them are devoid of pigment and uniformly whitish.

Youngest of the females collected (Fig. 15) measures: Body length 6.4 carapace, length on the mid-line 2.9, same, including posterior lobes 3.6×3.2, width across frontal plates 2.4, 2nd thoracic segment, length on the mid-line 0.5, same including lateral lobes 1.4×2.2, 3rd segment, length on the mid-line 0.6, same, including dorsal plates 0.7×1.4, 4th segment on the mid-line 0.5, same, including dorsal plates 0.8×1.3, genital segment, length on the mid-line 1.3, same, including posterior processes 1.4×1.3, 6th segment 0.3×0.5, abdomen 0.5×0.6.

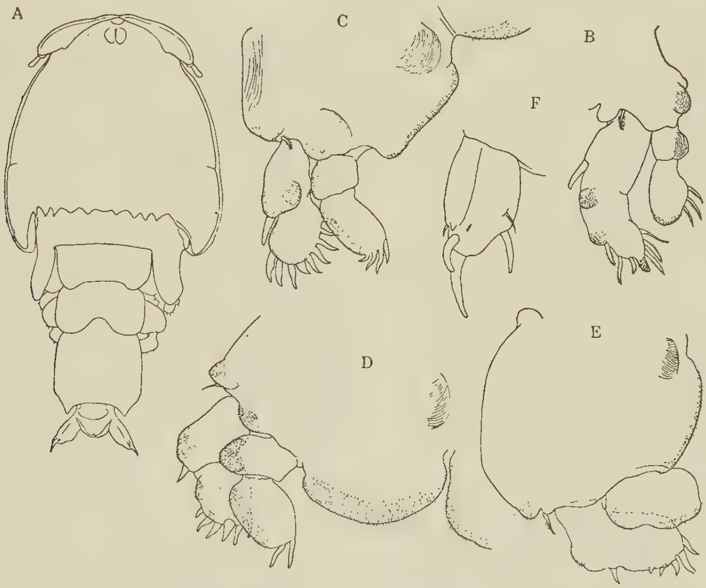


Fig. 15. *Pandarus satyrus* DANA, young female. A, a young female, dorsal view; B, 1st leg; C, 2nd leg; D, 3rd leg; E, 4th leg; F, caudal ramus. A ×8.7; B-E ×38; F ×31.

Spines along posterior border of carapace are relatively large-sized, triangular denticles. Dorsal plates of 3rd to 5th segments only slightly expanded on either side. Posterior processes of genital segment rather rudimentary. Median plate of 6th segment small, transversely elliptical, exposing greater part of abdomen. Ventral plate of the latter sami-circular. Thoracic legs substantially the same as those of the adult, though much feebler. Caudal rami somewhat different, more stumpy, and bearing 3 curved long spines as well as 2 minute ones.

The chief changes accompanying the growth consist in the gradual expansion of the dorsal plates on thoracic segments and the transformation of the posterior processes in genital segment.

Younger males: Two stages prior to the adult one were discovered in the present collection (Fig. 17, E & F). In the stages 7.9 mm long, paired membranes on posterior border of carapace are small, triangular, and consist of an opaque central area and a narrow, transparent surrounding rim. In the next stage of 8.7 mm long, those have grown to obovate plate having similar structure. Posterior lobes of genital segment in both of them smaller than in mature males and blunt at their apices.

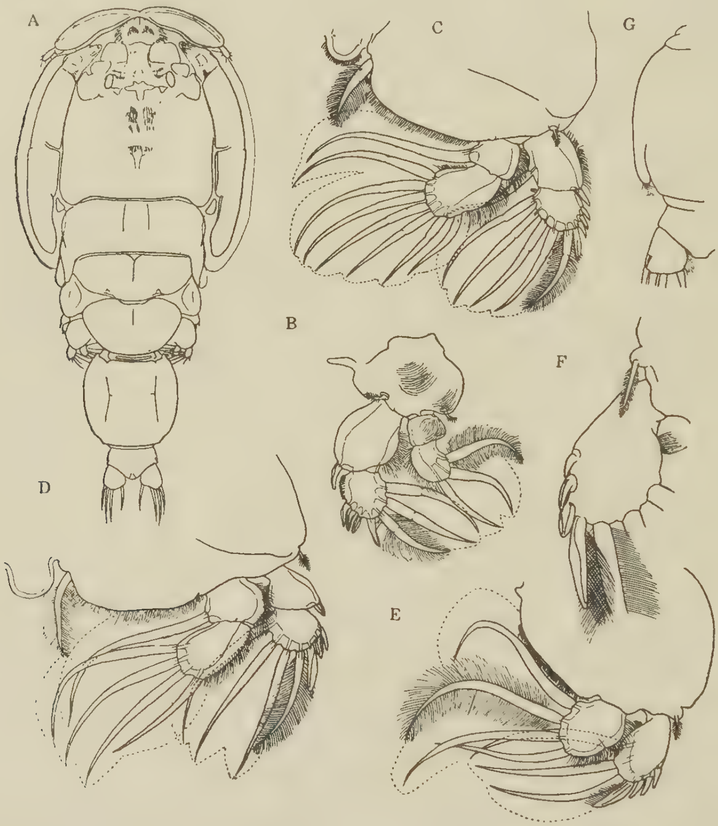


Fig. 16. *Pandarus satyrus* Dana, young male. A, young male of copepodid-stage, dorsal view; B, 1st leg; C, 2nd leg; D, 3rd leg; E, 4th leg; F, exopodite of same; G, genital segment, ventral view. A ×8.7; B-E ×31; F ×62; G ×20.

The youngest of the specimens collected is a form coincident with *Specilligus* of Dana, which has been rectified by Wilson as to represent a copepodid-stage of male Pandarids. It differs essentially from the adult in its structure, as it is somewhat convex both dorsally and ventrally. It is, accordingly, entirely opaque and uniformly pale brownish in color. Measurements in mm: Body length 7.1, carapace, length on the mid-line 2.8, same, including posterior lobes 3.6×3.3, width across frontal plates 2.5, 2nd thoracic segment,

length on the mid-line 0.8, same, including lateral lobes 1.3×2.2, 3rd segment 0.7×1.8, 4th segment 0.8×1.5, genital segment 1.4×1.4, abdomen 0.5×0.7.

Carapace relatively narrow, longer than wide, anterior part traversed by irregular, but symmetrically arranged rugae. Anterior border arched in a V-shape, framed with rather broad frontal plate. Lateral areas very narrow, a quarter as broad as central area from which they are separated by longitudinal grooves running parallel with widely round lateral margins. They are produced back into linguiform posterior lobes and rimmed with moderately broad marginal membrane. Posterior border very slightly sinuous, bearing a small, triangular, isolated, chitinous plate on either extreme end. Conspicilla glistening and widely apart.

Second thoracic segment quadrate, 3 and half times as long as carapace and about a third as long as its own width. It has uniform length throughout its width, but the extreme lateral ends are produced backwards into linguiform lobes, which come in contact with sides of following segment from outside. Third segment a little narrower and shorter, with semi-circular hind border and blunt lateral ends. Following segment farther narrower, but again a little longer, as long as 2nd segment, wider anteriorly than posteriorly and blunt at lateral angles. Genital segment as long as wide, with gracefully curved sides. Fifth leg rudiments present on ventral surface near posterior ends of lateral margins as a pair of processes which are dactyliform, directed backwards and tipped with 2, short, plumose spines. Sixth legs undeveloped. Abdomen small, wider than long; 1st segment in the form of a narrow, transverse belt inserted between genital segment and well-formed, pentagonal 2nd segment.

Appendages resembling those of the adult in structure. But, the spines on the legs fewer in number as indicated in the table below. Besides, both rami of 4th legs composed of only a single joint.

Legs	Borders	Sternal plate	Protopodite	Exopodite		Endopodite	
				1st joint	2nd joint	1st joint	2nd joint
I	outer inner		1p 1p	1H c	C, 4H 3P		c 3P
II	outer inner	c	1p 1P, c	c, 1H 1P	4H c, 5P	c 1P	c c, 7P
III	outer inner	c	1p 1P, c	1H c	3H c, 4P	c 1P	c 4P
IV	outer inner		1p c	c, 3H c, 4P		c 4P	

Remarks: *P. satyrus* DANA is very close to *P. cranchii* LEACH. They are

said, according to Wilson (1907), to be discriminated by the dorsal plates of the 3rd and 4th segments, which are unequal in size in the former, whereas approximately equal in the latter. They are distinguished also by the constitution of the male, especially by the structure of genital segment. In *cranchii*, postero-lateral angles of this segment extend beyond the end of the segment as sharply pointed, large, triangular lobes, while in *satyrus*, those are shorter, scarcely surpassing the posterior border, and somewhat blunt at their apices. Posterior lobes of the 2nd thoracic segment are more divergent in the present

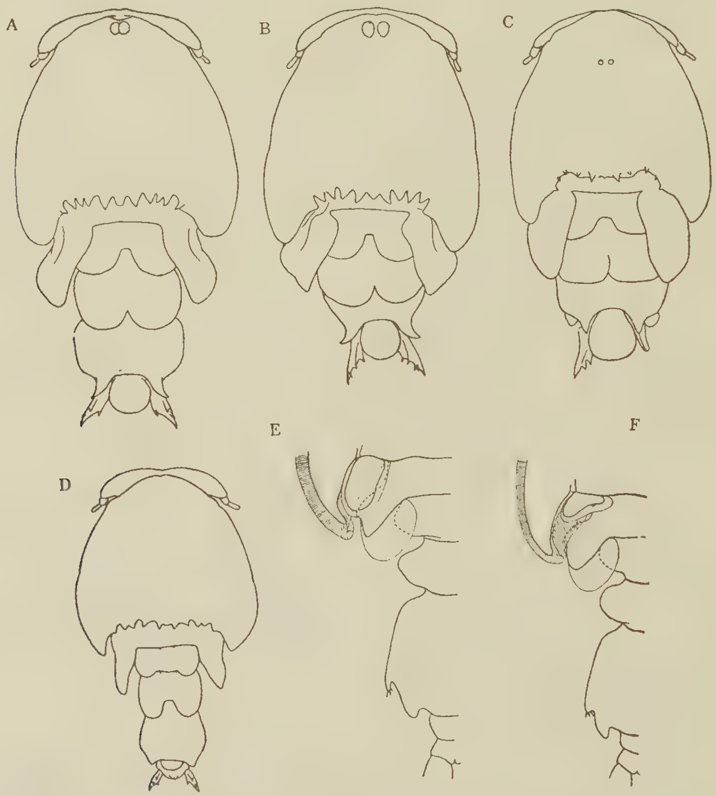


Fig. 17. *Pandarus satyrus* Dana, younger stages. A, a young female of 7.1 mm length; B, same of 6.2 mm length; C, same of 6.1 mm length; D, same of 5.5 mm length; E, postero-lateral part of male of 8.7 mm length; F, same of 7.9 mm length. A-F ×7.5.

species than in *cranchii*. Wilson's figure on the male of *cranchii* (1907, Pl. XXVIII, Fig. 132) is not correct as regards the constitution of this segment as pointed out by Heegaard (1943). The 3rd and 4th thoracic segments which are equal in size in *cranchii* are unequal in *satyrus*, the posterior segment having a shorter width.

P. cranchii reported by Steenstrup and Lütken (1861) is a synonym of

satyrus according to my opinion. General constitution of the body and the structure of the appendages are in complete agreement with those described and figured above. A parasite figured by RATHBUN (1886) under the name of *cranchii* seems to belong to *satyrus* also. BRADY's *zygaenae* (1883), which has been suggested by WILSON as synonymous with *satyrus*, is believed to represent an immature female of this species, as this may be clear from the comparison of BRADY's Pl. LV, Fig. 13 with my Fig. 17.

Genus *Demoleus* HELLER, 1865

Demoleus latus n. sp.

(Figs. 18 & 19)

Occurrence: On the body surface of *Acanthidium eglantina* (JORDAN & SNYDER) taken by Prof. Y. OKADA off Kannoura, Tokushima Pref. at a depth of 200–400 m; 3 adult females, and 3 younger ones belonging to 2 different stages.

Female: Body flattened, grayish brown in alcohol. Measurements in mm: Body length 8.8, carapace, length on the mid-line 2.6, same, including posterior lobes 3.8×3.6, frontal plates, width 2.6, 2nd thoracic segment, length on the mid-line and width at the base 0.4×1.8, same, including lateral lobes 1.1×2.3, 3rd thoracic segment 0.6×1.5, 4th segment, length on the mid-line 0.7, same, including dorsal plates 1.4×2.4, genital segment, length on the mid-line 2.2, same, including dorsal plates 3.6×2.8, 6th segment plate 2.8×2.8, abdomen 1.3×2.7, caudal rami 2.3×1.6.

Carapace about as long as wide including posterior lobes, anterior margin arched in the form of a flattened V. Frontal plates comparatively narrow, with margin gracefully curved and shallowly notched on the median; lateral ends of the plates freely projecting for a short distance as narrow, blunt lobes. Central area squarish, only slightly longer than wide, about 3 times as broad as lateral areas. These latter widely round on sides, but with a very slight notch about the middle and fringed by narrow membraneous rims. Posterior lobes blunt, linguiform, extending back about 2/5 the carapace length and a little beyond the tips of lateral lobes of 2nd thoracic segment. Longitudinal dorsal grooves only slightly concave inwards, but curved outwards near their anterior ends reaching lateral margins short distance behind the frontal plates. Posterior border very slightly arched forwards. Eyes distinct.

Second thoracic segment short but wide, about 1/5 as long as carapace and half as wide at its anterior end. Lateral lobes well developed, their acuminated apices directed backwards, exceeding posterior boundary of following segment; they bear narrow rims along both outer and inner margins. Third segment as long as 2nd, but narrower, with 2 round sides not covered by lateral lobes of the

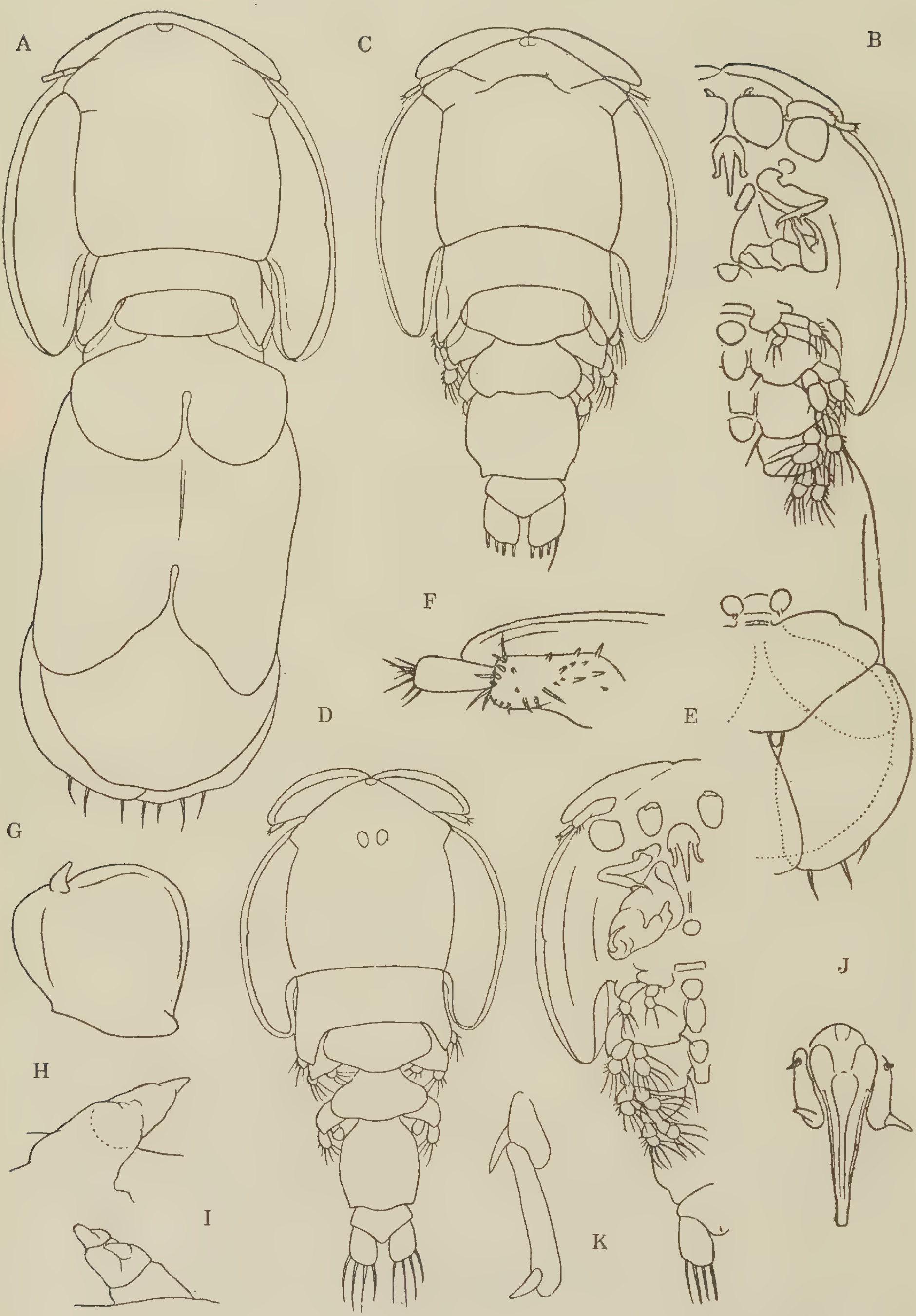


Fig. 18. *Demoleus latus* n. sp. A, female, dorsal view; B, same, ventral view; C, younger female, dorsal view; D, further younger female, dorsal view; E, ventral view of young female shown in C; F-K, adult female; F, 1st antenna, ventral view; G, 2nd antenna of right side, viewed from inner face; H, terminal joint of same, viewed from same face; I, same, ontside view; J, mouth tube with maxillae; K, maxillae further enlarged. A-E ×12; F ×58; G, J ×37; H, I ×170; K ×88.

latter. Fourth segment articulated with 3rd by a very short neck, behind which it expands abruptly in a pair of orbicular dorsal plates covering anterior part of following segment. The plates nearly straight, slightly inclined postero-laterally on anterior borders, well round on posterior sides and fused together on the mid-line, leaving a narrow, deep sinus. Genital segment elongate, broad, about as long as carapace including posterior lobes and 4/5 as wide. Lateral margins nearly parallel, continuing to gracefully round antero-lateral corners, and produced posteriorly in a pair of triangular dorsal plates. The plates have blunt apices, and interpose between each other a wide, V-shaped excavation which deepens farther to form a narrow crevice along the mid-line. Sixth segment a circular median plate, as long as wide and equal to genital segment in width which covers its anterior part. Abdomen entirely concealed beneath the named plate, twice as broad as long, rhombic, with antero-lateral margins sinuous, posterior margin in the form of a V, and with a small median dactyliform process. Both 6th segment and abdomen articulated by very narrow, short waist with ventral surface of genital segment at the bases of its dorsal plates.

First antennae with distal joint short, tipped by setae; proximal joint relatively narrow, twice as long as distal one, with spines more sparse and covering wider area than in ordinary case. Second antennae close to each other on the mid-line. Basal joint expanded in oval pad, bearing small, spiniform, apical joint at its antero-internal angle; the latter incompletely 3-jointed and bearing tiny spinules. First maxillae absent. Second maxillae close to either side of the base of narrow, elongate, conical mouth tube; each of them club-shaped, directed backwards, issuing externally a small spiniform distal joint from the apex and a similar but feebler spine from the base. First maxillipeds with joints relatively thick and short. Terminal spine stout, broadest about the middle of its length, somewhat narrowing proximally and acuminating distally to a point. Its distal half circumscribed on all sides with transverse rows of minute hairs, which are longer at broadest part of spine; proximal half hairless, but with a tuft of further longer, stiff hairs at the very base. Accessory spine standing at a right angle to the segment a little behind the terminal one, much smaller and with minute hairs in its distal half. Second maxillipeds strong; palm rugged on surface, irregular in shape, with apical part produced in a spiniform process, which, together with similarly-shaped terminal claw, forms forceps resembling a chela of crab.

Arrangement of adhesive pads on ventral surface of carapace is as follows: A pair of large squarish pads just behind the bases of 1st antennae; another pair of similar, but somewhat larger pads formed by basal joints of 2nd antennae; another much smaller pair inside the bases of 1st maxillipeds and closely adjoining on the mid-line; a single, median, oval one, placed just behind and



Fig. 19. *Demoleus latus* n. sp. A-G, adult female; A, 1st maxilliped; B, 2nd maxilliped, posterior view; C, same, anterior view; D, 1st swimming leg; E, 2nd leg; F, 3rd leg; G, 4th leg; H-K, young female shown in Fig. 18, C; H, 2nd antenna; I, terminal joint of same; J, 2nd maxilliped; K, posterior extremity of body, ventral view. A ×58; B, C, H, K ×37; D-G ×49; I ×117; J ×41.

between the bases of 2nd maxillipeds; another median one between the bases of first 2 pairs of swimming legs; last pair of elongate pads represented by ventral thickenings at anterior angles of lateral lobes of 2nd thoracic segment.

Thoracic legs biramous, having both rami 2-jointed in all. Endopodite of

1st legs much smaller than exopodite, but never rudimentary; exopodite expanded on outer border of 1st joint and protopodite with a small bulge on outer side. Other legs resemble those of ordinary Pandarids, having broadly expanded protopodites. Arrangement and number of spines and other armatures in each of them will be made clear from the following table:

Legs	Borders	Sternal plate	Protopodite	Exopodite		Endopodite	
				1st joint	2nd joint	1st joint	2nd joint
I	outer		1p	1p	c, 4H		c
	inner		1p	c	c, 3P		3P
II	outer	f	1h	c, 1H	c, 4H	c	c
	inner		1P, f	c, 1P	c, 5P	1P	c, 8P
III	outer	f	1h	f, 1H	f, 4H	c	c
	inner		1P, f	c, 1P	c, 5P	1P	c, 5P
IV	outer			f, 1H	3H	c	c
	inner		f	c	c, 5P	1P	c, 4P

Plumose spines on the legs well developed. Simple spines have very narrow marginal rims along 2 opposite sides in many cases. Most distal one of simple external spines on apical exopod joint of all legs except 2nd bears fine cilia on inner border, while a narrow membrane on the other border. Cilia fringing external margin of joints are united together to form a continuous striated membrane in 2 exopod joints of 3rd legs as well as in basal exopod joint of the last. Rudiments of 5th legs undiscovered.

Caudal rami greatly expanded, scalloped, with well round outer and straight inner borders, and attached to abdomen along its entire posterior border with their very broad bases. They are covered from above for the greater part by 6th segment plate and bear 3 or 4 marginal spines on posterior side. Egg cases are a pair of coiled tubes concealed within narrow space between 6th segment and caudal rami and adhere with their beginning ends to genital segment on either side of the base of the named plate.

The present collection includes 2 different stages of younger females. They resemble the adult stage in the constitution of anterior part of the body, differing in that of the posterior part and in the structure of some the appendages.

Young female (Figs. 20, C; 21, H–K): Measurements in mm: Body length 5.5, carapace, length on the mid-line 2.7, same, including posterior lobes 3.3×3.3, frontal plates, width 2.6, 2nd thoracic segment, length on the mid-line 0.7, same, including lateral lobes 1.3×2.0, 3rd segment 0.7×1.4, 4th segment 0.6×1.3, genital segment 1.0×1.3, abdomen 0.4×0.9.

Dorsal plates of 4th thoracic segment very rudimentary, represented by slight, triangular, posterior bulge on either side. Genital segment squarish, neither elongate nor bilobed as in the adult, with posterior end somewhat narrowed and angular on either corner. Abdomen short, small, triangular, with caudal rami of ordinary nature.

Basal joints of 2nd antennae smaller than in the adult, and apart from each other; distal joints divided at their apices into several processes. Second maxillipeds different from those of adult in structure. Palm more or less rugged on the surface, bearing a proximally-directed lancetform process on inner side, but not forming a forceps with terminal claw; The latter swollen at the base, acuminating towards curved tip and with a spine about the middle. Thoracic legs as in the adult except for 3rd pair in which distal joint of endopodite bears 4 spines instead of 5 of the adult. Fifth legs present on ventral surface of genital segment on its lateral margins and a short distance in front of its posterior border. They are a pair of dactyliform processes which bear a short spine. Caudal rami not expanded unlike those of adult, but like those of ordinary Pandarids, and with 4 plumose terminal spines and a row of short hairs on inner border. In other points as in the adult.

Further younger stage (Fig. 20 D, E): In general, resembling the stage treated above. Measurements: Body length 5.3, carapace, length on the mid-line 2.2, same, including posterior lobes 2.8×2.8, frontal plates, width 2.3, 2nd thoracic segment, length on the mid-line 0.6, same, including posterior lobes 1.1×1.8, 3rd segment 0.6×1.3, 4th segment 0.6×1.1, genital segment 1.0×0.9, abdomen 0.4×0.7.

Anterior border of carapace more prominent than in that stage, V-shaped, with frontal plates wider and more free. Posterior lobes shorter, not reaching the tips of lateral lobes of 2nd thoracic segment. Fourth segment without slightest rudiments of dorsal plates. Genital segment narrower, longer than wide, more or less flask-shaped. Appendages as in that stage.

Remarks: Demoleus has hitherto been represented by only a single species *D. heptatus* Otto. Although this species was recorded by a number of different names in the past, that they are all synonymous with *heptatus* was fully discussed by Dollfus (1943). In so far as I am aware no species has been added from that time onwards.

Comparison of the new species with the type is made possible through the studies of Gerstaecker (1853) and of Dollfus on the latter. The two species are distinguished from each other in the first place by that the posterior half of the body is relatively broader in the new species than in *heptatus*. The genital segment, for example, is about 3/5 as wide as carapace in the latter, while it is 4/5 in the former. They are different further in the configuration of the bifur-

cate end of the genital segment. In the type species, the 2 lobes of the segment are closely adjoining together leaving a narrow median sinus between each other, while in the new species they are widely apart by intrusion of a V-shaped excavation. The sixth segment plate, which is scarcely half as wide as the genital segment in the former, is greatly expanded attaining nearly the width of this segment. The abdomen is a small structure in *heptatus* not surpassing 1/3 the width of the 6th segment plate, but it is incomparably broadened in *latus* to such an extent that it does not fall behind the plate in width. Finally, the caudal rami of *latus* are unusual in outline being fan-shaped and proportionately far larger than the obovate rami of *heptatus*.

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Report of Faculty of Fisheries,
Prefectural University of Mie,
Vol. 1, No. 3, July 30, 1954.

Copepods Parasitic on Japanese Fishes

6. Two Species of the Family Cecropidae

(*With 6 Text-figures*)

SUEO M. SHIINO
Faculty of Fisheries, Prefectural University of Mie

The two species of parasitic copepods here dealt with are usually known to occur on *Mola mola*. The specimens were forwarded me by courtesy of Seto Marine Biological Laboratory, Kyoto University, but they were not accompanied with any record about the host names. Out of them, *Orthagoriscicola muricata* (KRφYER) has already been reported from Japan by SHISHIDO (1898) under the name of *Laemargus muricatus* KRφYER. His description of this parasite, which he found on the same host as named above, was rather brief and did not refer to the detail of its appendages. The other species, *Philorthragoriscus serratus* (KRφYER) is described for the first time from our country.

Genus *Orthagoriscicola* POCHE, 1902
Orthagoriscicola muricata (KRφYER), 1837

(Figs. 1–3)

Laemargus muricatus, KRφYER, 1837, Naturhist. Tidsskr., vol. 1, p. 487, pl. v, figs. A-E; 1863, p. 188; M.-EDWARDS, 1840, p. 475, pl. xxxix, fig. 2; BAIRD, 1850, p. 295, pl. xxxiv, figs. 3–4; HOEVEN, 1857, pl. ix; BENEDEN, 1861, p. 129, pl. xix, figs. 1–4; HESSE, 1886, p. 339, pls. xiv-xv; VALLE, 1880, p. 61; CARUS, 1885, p. 363; A. SCOTT, 1892, p. 266, pl. iii; SHISHIDO, 1898, p. 90; BASSETT-SMITH, 1899, p. 467; T. SCOTT, 1900, p. 158, pl. vi, figs. 39–42.

Orthagoriscicola muricata, POCHE, 1902, Zool. Anz., vol. 26, p. 13; BRIAN, 1906, p. 56; 1908, p. 5; 1912, p. 14, pl. ii, figs. 1–2, pl. vi, figs. 5–8; WILSON, 1907, p. 473, pls. xl-xli; 1932, p. 443, fig. 279; STEBBING, 1910, p. 559; T. & A. SCOTT, 1913, p. 100, pl. xxi, fig. 5, pl. xxviii, figs. 8-18.

Occurrence: On unknown host, off the coast of Wakayama Pref.; 3 females and 2 males.

Distribution: Cosmopolitan. European coast of Atlantic (KRφYER, M. EDWARDS, BAIRD, BENEDEN), Mediterranean (VALLE, CARUS, BRIAN,) Bristish seas (A. & T. SCOTT), North Atlantic (BRIAN), Table Bay, S. Africa (STEBBING), Woods Hole (WILSON). Parasitic on *Mola mola* and *Selene vomer*.

A distinct sexual dimorphism is observed.

Female: Body wider posteriorly than anteriorly and strongly convex dorsally; brownish yellow in alcohol, claws, spinules, and ribs on carapace tinged with dark brown. Measurements in mm: Body length 15.7, carapace 5.1×6.9,

2nd thoracic segment 0.5×5.1, 3rd segment 0.8×3.8, 4th segment 6.2×9.2, genital segment 9.2×10.5, abdomen 6.2×11.1.

Carapace 1/3 as long as body, 3/4 as long as wide, trapezoidal, narrowing anteriorly, and with large, well-round posterior lobes. Anterior border entirely fused with frontal plates, with a median notch, widely round on either side of it, and bearing prominent lateral bulges at antennal bases. Lateral margins thickly beset with sharp spines. Posterior border somewhat convex in median region. Surface of carapace more or less rugged, traversed by rather indistinct grooves and sparsely covered with sharp spines. Eyes invisible.

Second and 3rd thoracic segments free, very short and narrow, without dorsal plate, and in the form of a waist joining the carapace with posterior segments. Second segment a little wider than 3rd; lateral parts of the former pointed, concealed beneath carapace, while those of the latter obtuse and exposed. Each of the 2 segments bears a transverse carina on ventral surface between limb bases of right and left. Fourth segment short on the mid-ventral region, but expanded dorsally in a pair of dorsal plates, larger than carapace and covering anterior half of genital segment. The plates largely fused with each other, being separated only by a shallow posterior crevice and with widely round, finely serrated free borders. Genital segment with length on mid-ventral line equal to that of foregoing 3 segments combined. Dorsal plates longer than those of 4th, completely covering abdomen, and overlapping each other along the mid-line. Their round posterior borders bear denticles larger and coarser than in 4th segment plates. Abdomen strongly expanded on either side into round lateral lobe, forming, as a whole, a semicircular segment, which is nearly as long as carapace and twice as wide. Its posterior border bilobed, bearing caudal rami some distance in front of its extreme end. Egg strings very long and coiled, carried in the space between dorsal plates of genital segment and abdomen.

First antennae with rod-like flagellum and wider peduncle, both consisting of 2 joints; distal joint of peduncle covered with tubercles on anterior face, each of these surmounted with a short spine. Second antennae 3-jointed; 1st joint dilated inwards, 2nd nodose, and 3rd a sharp, strongly curved, powerful hook, with a spine at about the middle of its length and another one close to its base. Oral tube slender, elongate conical, and projecting backwards from a broad, short, cylindrical base. Maxillae narrow, triangular, simple lamellae, placed on either side of oral tube. First maxillipeds stout, with joints rather broad in relation to their lengths; distal joint subdivided into 2 false joints. Terminal claw thick, attenuating towards the tip, and heavily armed with stout spinules. Accessory claw placed a short distance behind, much smaller, in the form of a large spine bearing rows of cirri along 2 borders. Standing side by side with accessory claw, there is a conical knob thickly beset with spinules. Second

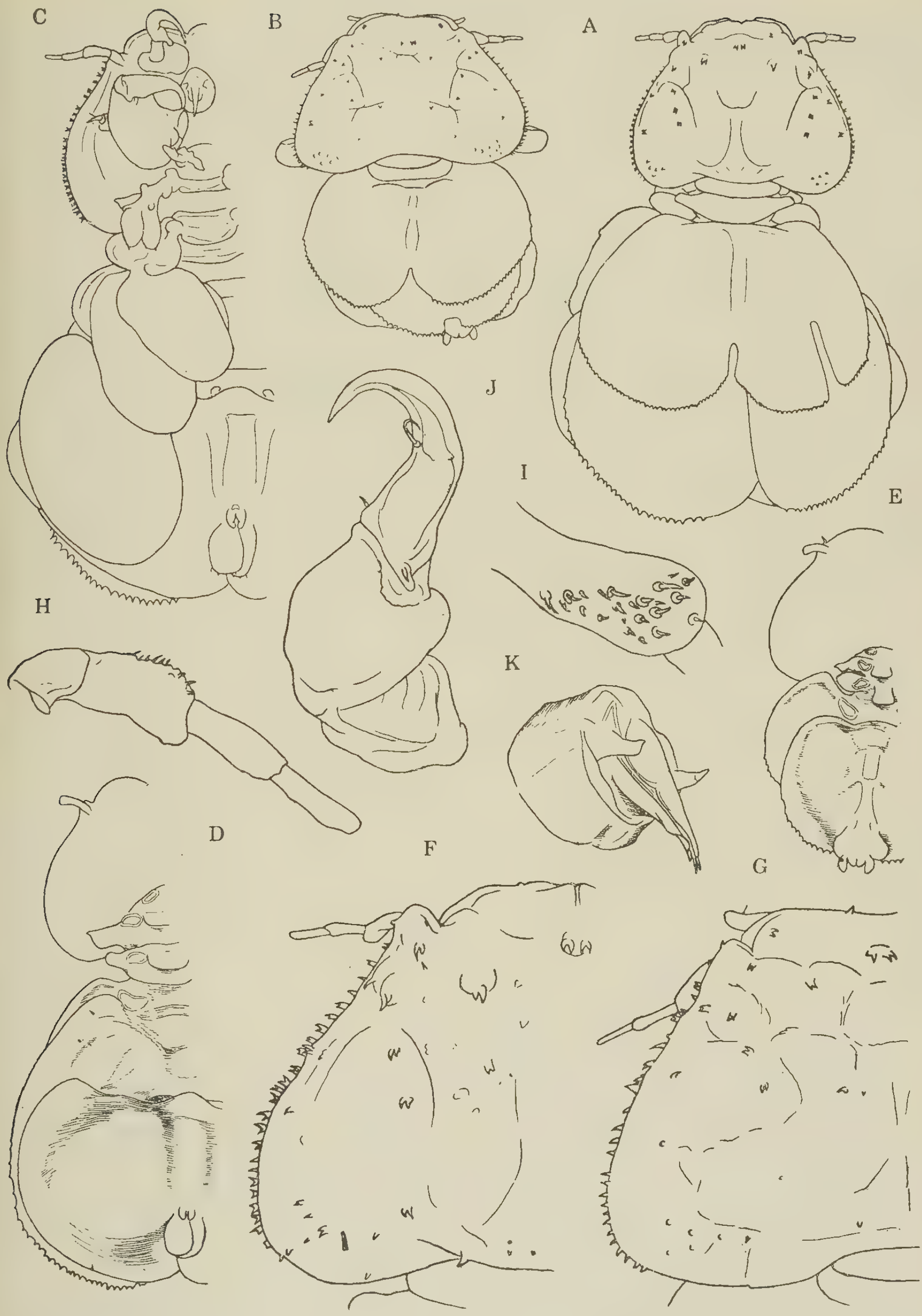


Fig. 1. *Orthagoriscicola muricata* (KRØYER). A, female, dorsal view; B, male, dorsal view; C, female, ventral view; D, same, with appendages removed; E, male, ventral view, with appendages removed; F, female, carapace, dorsal view of left half; H-K, female; H, 1st antenna; I, same, 1st joint of peduncle; J, 2nd antenna; K, mouth tube with maxillae. A, B, D, E ×4.3, C ×4.7, F, G ×10, H ×27, I ×41, J, K ×19.

maxillipeds powerful, composed of large, inflated palm and strong, well-curved, relatively short claw. Inner face of palm provided with a small, mammiform tubercle close to the base of claw, another small tubercle as well as a pointed, conical, large bulge at about the middle and a pair of low, broad ridges at the base.

All legs biramous, with rami destitute of plumose spines except for a



Fig. 2. *Orthagoriscicola muricata* (Krøyer), female. A, 1st maxilliped; B, apical spines of same, further enlarged; C, 2nd maxilliped; D, 1st thoracic leg, anterior face; E, same, posterior face; F, same, another face, somewhat further enlarged; G, 2nd leg, posterior face; H, same, anterior face; I, 3rd leg, posterior face; J, 4th leg, anterior face; K, caudal rami. A ×32, B ×83, C, K ×12, D, E ×27, F ×41, G, H ×19, I ×6.3, J ×10.

short, simple one. First 2 pairs of them small, with 2-jointed rami, while last 2 pairs several times larger, and composed of lamellar protopodite and non-articulated, obovate, flattened rami. Protopodite of 1st legs with 2 corrugated bosses on anterior face, one on outer border and the other on inner border. Their rami very narrow, outer one exceeding inner one in length. First joint of endopodite with corrugated boss, 2nd joint with 2 tubercles placed at either angle of its apical border, and 1st joint of exopodite with a process at outer distal angle. Second legs larger than 1st; protopodite has 5 corrugated bosses, which are arranged 2 at outer distal angle of the joint closely adjoining together, and each of the rest at the base, at inner distal corner and just behind the base of exopodite respectively. First joint of endopodite also with a similar boss, while that of exopodite with a short, terminal spine. Second joint of both rami foliaceous, more or less tubercular on margin. Third legs smaller than 4th and with a corrugated boss on inner margin of protopodite. Exopodite larger than endopodite in both pairs, that of 4th attaining nearly the length of carapace. Spines are arranged in each pair of legs as shown in the following table*:

Legs	Borders	Protopodite	Exopodite		Endopodite	
			1st joint	2nd joint	1st joint	2nd joint
I	outer inner	1p 1p	— —	4h —	— —	1h —
II	outer inner	1s —	1h —	4h, 1s —	— —	1h —
III	outer inner	— —	4h —	— —	— —	— —
IV	outer inner	— —	4h —	— —	— —	— —

Caudal rami completely concealed beneath abdomen. They are foliaceous, with 4 or 5 short spines along broad terminal border, and with a small acuminate process on outer margin at the base. Anal region protrudes as a pair of oval ridges between bases of caudal rami.

Male: Smaller than female. Measurements in mm: Body length 10.3, carapace 4.9×7.4, 2nd thoracic segment 0.5×3.1, 3rd segment 0.3×2.8, 4th segment 4.9×7.2, genital segment 4.5×5.5, abdomen 1.2×1.9.

Carapace resembling that of female, but proportionally wider, 3/5 as long as wide, and 2/5 as long as body. Anterior border broader, and posterior border

* Abbreviations used in the tables:

C, row of cirri; c, row of setae; f, membraneous flange; H, longer simple spine; h, shorter simple spine; P, longer plumose spine; p, shorter plumose spine; s, solitary hair.

concave in central region. Second and 3rd thoracic segments relatively narrower, with lateral parts covered by carapace and with sternal carinae much narrower. Dorsal plates of 4th segment nearly as large as carapace, circular on either side, but fused together leaving a median sinus; posterior border with fine serration. Genital segment largely covered by 4th, elliptic, wider than long, and about as



Fig. 3. *Orthagoriscicola muricata* (Krøyer), male. A, 2nd maxilliped; B, 1st thoracic leg; C, apical exopod joint of same, further enlarged; D, apical endopod joint of same; E, 2nd leg; F, apices of both rami of same, further enlarged; G, 3rd leg; H, apices of both rami of same, further enlarged; I, tip of endopodite of same, posterior view; J, 4th leg; K, abdomen with caudal rami. A, J ×10, B, E, G ×27, C, D, F, H, I ×83, K ×18.

long as carapace; dorsal plates of both sides largely fused except for a small, squarish, median excavation, and with serrated margin. Abdomen much smaller than in female, cordiform, fastened to ventral side of genital segment near its posterior margin.

Second antennae and 2nd maxillipeds proportionally larger than in female. Palm of the latter with a mammiform bulge about the centre of inner margin and a sharp conical process near the base; claw long, well-curved, with a rudimentary spine at its basal part. Third pair of legs unlike those of female, with rami narrowed, 2-jointed and somewhat resembling 2nd pair in appearance. Endopodite much larger than exopodite. Terminal armatures of the former consist of a curved, blunt, horny and black spine, a broad, spatulate, shrivelled membrane, ending in a sharp apex, and another curled membrane formed by fusion of curved hairs which stand in a row. Other legs as corresponding ones of female, but somewhat different in the arrangement of corrugated bosses. Those on 1st legs smaller and those on 2nd legs fewer in number, bearing only 2 on protopodite. Third legs with a boss on inner side of protopodite. Disposition of spines on thoracic legs may be shown by the following table. In other respects as in the female.

Legs	Borders	Protopodite	Exopodite		Endopodite	
			1st joint	2nd joint	1st joint	2nd joint
I	outer	1p	1h	4h	—	—
	inner	—	—	—	—	—
II	outer	1p	—	5h	—	1h
	inner	1h	—	—	—	—
III	outer	1p	1h	4h	—	2h
	inner	2h	—	—	—	1h
IV	outer	—	—	5h	—	—
	inner	—	—	—	—	—

Genus *Philorthragoriscus* Horst, 1897

Philorthragoriscus serratus (Krøyer), 1863

(Figs. 4–6)

Dinematura serrata, Krøyer, 1863, Naturhist. Tidssk., ser. 3, vol. 2, p. 106, pl. viii, figs. 4a–i; Bassett-Smith, 1899, p. 463; T. Scott, 1901, p. 125.

Philorthragoriscus serratus, Horst, 1897, Notes Leyden Mus., vol. 19, p. 137, pl. vii; Brian, 1906, p. 53, pl. i, fig. 4, pl. xvi, figs. 1–7; 1908, p. 110; 1912, p. 12, pl. ii, fig. 3, pl. vi, fig. 9; Wilson, 1907, p. 479, pls. xlii–xliii; 1932, p. 445, fig. 280; T. & A. Scott, 1913, p. 104, pl. xxiv, figs. 3–4, pl. xxvii, figs. 11–24.

Occurrence: A single female on unknown host; off Wakayama Pref.

Distribution: European coast of North Atlantic (Horst, T. & A. Scott, Brian), Woods Hole (Wilson). On *Mola mola*.

Female: Body flattened, color brownish yellow in alcohol, egg strings yellow. Measurements in mm: Body length 8.1, carapace, length on the mid-

line 3.1, same, including posterior lobes 4.1×5.5, 2nd+3rd thoracic segments 1.1×4.0, 4th segment 2.7×5.1, genital segment 3.7×4.7, abdomen 1.3×2.2.

Carapace about 2/5 as long as body on the mid-line, 4/7 as long as its own width, more or less flattened. Anterior border smooth, widely round, with a shallow, broad, median incision, and with frontal plates completely coalesced. Lateral margins well round, having a slight sinus about the middle on each side and rimmed with short, acuminate, uniformly distributed spines. Posterior margin

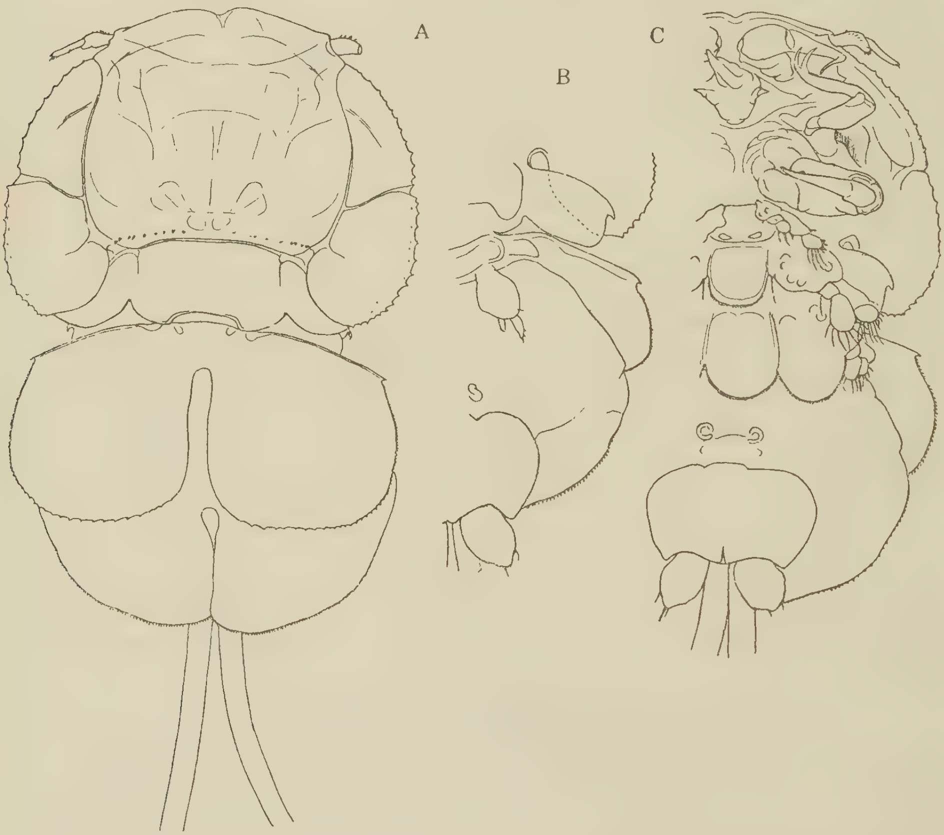


Fig. 4. *Philorthragoriscus serratus* (Krøyer), female. A, female, dorsal view; B, same, postero-lateral part of body, with first 3 thoracic legs removed; C, same, ventral view. A, C ×10, B ×19.

slightly arched forwards, with similar spines arranged in a row parallel with and a little in front of extreme margin. Surface grooves distinct; longitudinal grooves concave towards each other, but curving outwards near their anterior ends to reach lateral borders just behind the antennal bases. Central area nearly quadrilateral, a little wider than long and occupying 2/3 the entire width of carapace. Lateral areas subdivided on each side into narrower anterior and broader posterior areas by a transverse groove running from lateral sinus postero-

internally to join longitudinal groove. Posterior areas extending near the level of hind border of succeeding segment as round lobes, and furnished with row of fine spinules close to and parallel with lateral margins.

Second and 3rd thoracic segments entirely fused together. The composite segment 3/4 as wide as carapace, with oval lateral plates, and a pair of notches on posterior border. Terminal part of each of the plates covered by posterior lobe of carapace and with a small, curved spine at anterior corner. Fourth segment with dorsal plates strongly expanded, covering anterior half of genital segment. Those of both sides united anteriorly for a short distance, remaining separated posteriorly by a deep, narrow, median sinus. Their combined anterior border a little shorter than carapace width, forming a graceful arc and terminating laterally in a small, acuminate spine; posterior and lateral margins well round, finely and densely serrated. The plates bear, further, a blunt process on ventral surface close to limb base of either side. Genital segment of large size, about equal in width to 4th segment plates, wider than long, elliptic in shape and bilobed posteriorly by median incision extending to its centre. Each lobe flattened, with well-round, very finely serrated, outer and straight, smooth, inner borders. Abdomen attached to ventral surface of genital segment at about its centre and entirely invisible from above. It is relatively large, wider than long, about half as wide as preceding segment and has well round sides which terminate posteriorly in angular corners; posterior margin somewhat undulated. Egg strings very long, trailed backwards.

First antennae as usual, bi-articulated. Terminal joint as long as basal one, cylindrical, with a solitary hair about the middle of its length in addition to apical bunch of short setae; basal joint exposed, relatively narrow, with antero-dorsal margin covered by spiny tubercles. Second antennae stout; terminal joint curved in a strong, sharp hook, with minute basal and central spinules, and rest 2 joints cylindrical. Mouth tube elongate conical. Maxillae spiniform, directing outwards, each of them ending in a short spine and with a rudimentary, accessory branch close to the base. First maxillipeds with joints and claws rather thick-set; 2 apical claws about equal in size, curved, attenuating towards the tips, and with several rows of fine cirri on outer border besides a similar row along inner border. On posterior side of the base of inner claw, there is an elongate conical, third claw, which is about half as long as others and surrounded with cirri on all sides. Second maxillipeds strong. Their claw sharp, well-curved, with a small, quadrate process on anterior side near the base and a minute hair on the opposite side. Palm elongate triangular, bearing a prominent, quadrate bulge, ending in spiniform apex on inner face near the base and a round, more or less rugged bulge at the base.

All pairs of legs biramous. First 3 pairs resembling corresponding pairs



Fig. 5. *Philorthragoriscus serratus* (Krøyer), female. A, 1st antenna, posterior view; B, same, anterior view; C, 2nd antenna; D, mouth tube with maxilla, lateral view; E, 1st maxilliped; F, tip of same, further enlarged; G, 2nd maxilliped, posterior view; H, same, anterior view; I, caudal ramus of right side; J, lateral border of carapace; K, lateral border of dorsal plate of 4th thoracic segment. A-E, I-K ×41, F ×83, G, H ×27.

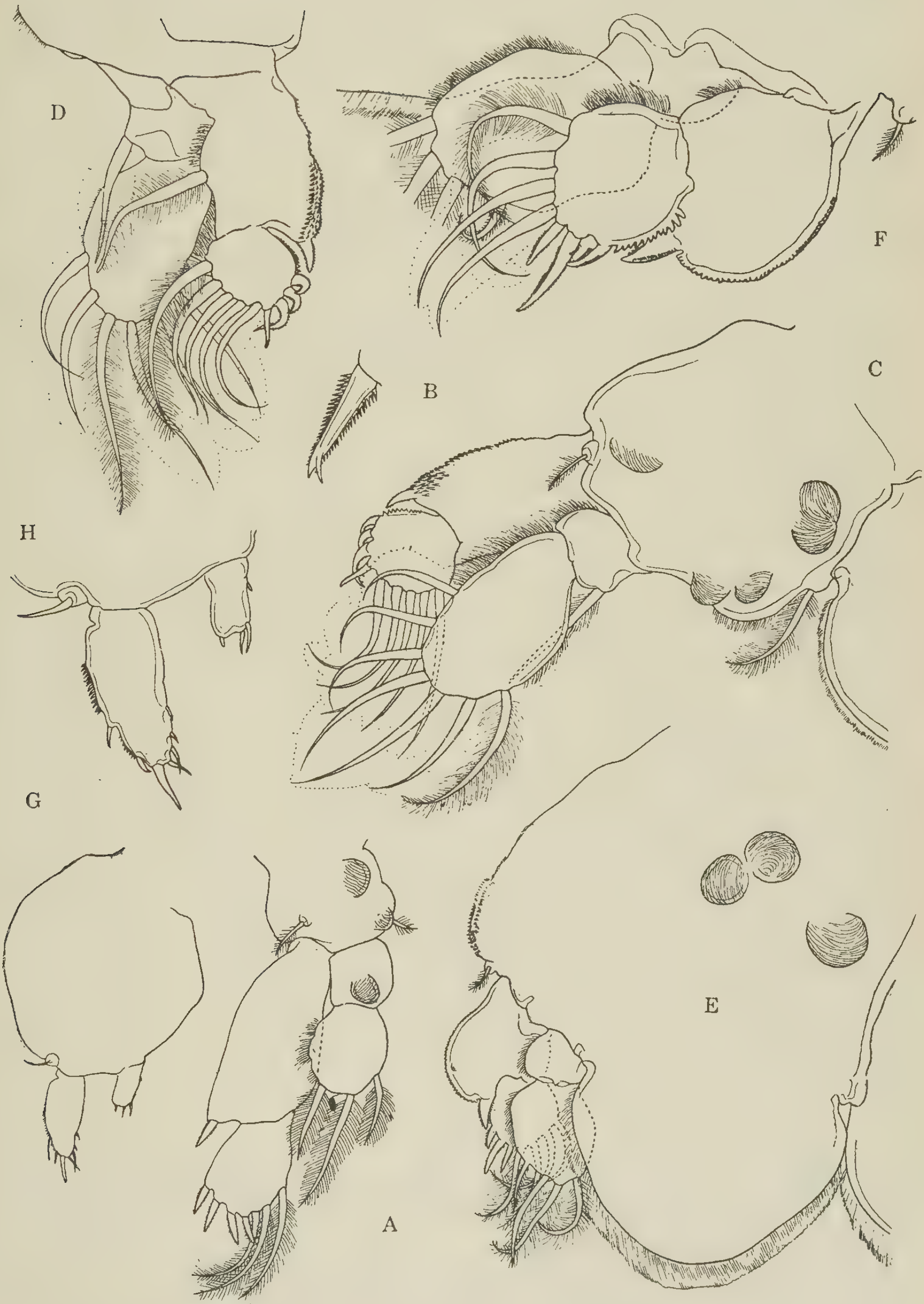


Fig. 6. *Philorthragoriscus serratus* (KRØYER), female. A, 1st thoracic leg; B, apical spine of same; C, 2nd leg; D, same, posterior view; E, 3rd leg; F, 2 rami of same, posterior view; G, 4th leg, posterior view; H, 2 rami of same. A-E ×41, F, H ×83, G ×10.

of other Caligoida in structure, with biarticulated rami, fringed with plumose spines. First pair small, with protopodite not dilated and with exopodite longer than endopodite. Protopodite of succeeding 2 pairs strongly expanded, that of right and left in each pair combined by a median sternal plate. In exopodite of those 3 pairs, distal joint is longer or larger than proximal joint, while in endopodite the relation is reversed. Last legs small, composed of dilated protopodite, and 2 rudimentary unjointed rami, lacking plumose spines. Spines and other armatures are arranged in each pair of legs as shown in the following diagram:

Legs	Borders	Sternal plate	Protopodite	Exopodite		Endopodite	
				1st joint	2nd joint	1st joint	2nd joint
I	outer inner		1p 1p	1H	4H 3P		c 3P
II	outer inner	f	1p 1P, c	C, 1H c, 1P	C, 4H 5P	c 1P	c 7P
III	outer inner	f	C, 1p f	C, 1H c	C, 3H c, 4P	c	c c, 4P
IV	outer inner		1H	C, 1h, C, 1h 4h, 1H		1h 3h	

Simple spines on first 3 pairs of legs with fine serration along 2 opposite margins. First legs with 2 corrugated bosses on anterior face of protopodite and 1 on the same face of 1st endopodite joint. Protopodite of 2nd legs with 4 of them, arranged 3 on inner border and 1 near the base of exopodite. Third legs with 3 of them near the base of protopodite. Fourth legs without boss. Each joint of exopodite of 3rd legs and 2nd joint of the same ramus of 2nd legs finely serrated on outer border. First joint of the latter, protopodite of 3rd legs and exopodite of 4th with several rows of spinules along outer border.

Caudal rami oval lobes, divergent backwards, and with 4 or 5 short simple spines on terminal margin.

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Influence of Diluted Sea Water on the Pearl Oyster, "*Pteria* (*Pinctada*) *martensi* DUNKER"

N. Y. KAWAMOTO and E. MOTOKI
Faculty of Fisheries, Prefectural University of Mie

Thorough investigations of morophology of the pearl oyster, "*Pteria* (*Pinctada*) *martensi* DUNKER", have been made by many researchers, but physiological nature of this species has not yet been adequately studied, in spite of the introduction of efficient improvements in the manipulating technique of pearl culture.

For this reason, the present writers initiated this physiological study at the laboratories of Shimamura Pearls Farm and Nippon Institute for Scientific Research on Pearls in Shima district, Mie Prefecture.

Methods of experiments

The kymograph has been used extensively to record the heart pulsations and motions of terrestrial animals in the physiological studies if cardiac characteristics. Also, in investigating the physiology of aquatic animals, especially of *Lameribranchiata*, data on cardiac action and reaction is considered to be very significant, for the heart beat is directly influenced by the different physical and chemical factors associated with the environmental water.

To clarify the influence of the salinity of the sea water on the pearl oyster, the authors first studied the heart pulsation of the shell in sea water of various salinities. The heart was cut from the body by severing the aorta near the ventricle, after being tied at the end of the ventricle by a slender silk string so the heart was not isolated from the body, and conditions were as natural as possible. The string was connected to the lever and its motions recorded on the drum of the kymograph. The heights of amplitude of the heart pulsation were enlarged three times by the lever in these experiments.

The string was not tied at an auricle because there are two auricles laying parallel, somewhat separated, and mainly because they are too delicate for tying.

Results of experiments

(a) On the relation between heart beat and salinities in the environmental sea water

Experiment 1: The experiment was done to see roughly how the heart

beat reacted to diluted sea water, and the change in heart beat in various salinities from normal sea water to one tenth normal concentration were observed. Heart beat recovery when the heart was returned to the normal solution was also observed.

Table I. On the heart beat in the various concentrations of sea water. (Studies were performed on each heart in order from No. 1 to No. 8 and the results of five experiments were averaged.)

No.	Kind of sea water	Frequency of heart beat (per 1 min.)	Amplitude of pulsation (average)	Remarks
1.	Natural sea water	28-30	7 mm.	——
2.	1/2 diluted sea water	35	about 9 〃	Large amplitude once in three times.
3.	1/3 〃	24-22	about 8 〃	Numbers gradually decreased.
4.	1/5 〃	15-14	10 〃	Regularly.
5.	1/6 〃	5-7	8-5 〃	Irregularly.
6.	1/7 〃	5-2	5-4 〃	——
7.	1/10 〃	None	——	——
8.	Natural sea water	7-10	7 〃	Became healthy gradually.

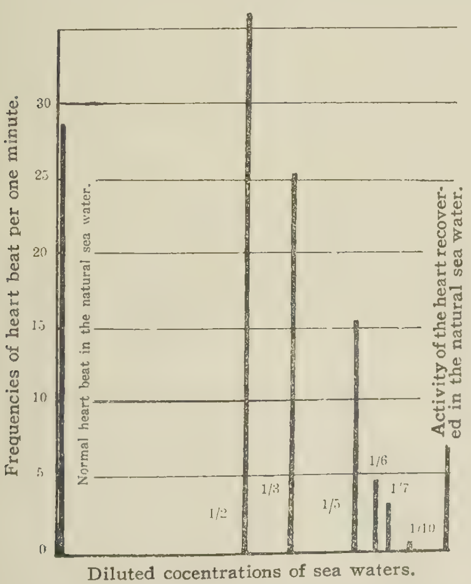


Fig. 1. Showing the change of the frequencies of heart beat in waters diluted from one half to one tenth the normal concentration of sea water, transferred from left to right.

The data in Table I are shown in Fig. 1 as follows:

The data in Table I show that numbers of the heart beat began to change gradually in waters diluted from one half to one sixth the normal concentration of sea water, became feeble rapidly in the one seventh and stopped soon in the one tenth. But, when transferred from the one tenth concentration to natural sea water, the activity of the heart recovered after three minutes. The experiments in this chapter were done in the time of three to ten minutes respectively and, therefore, the variations, which are seen in this table, only show the changes for a short time, and it will be supposed that the results may be varied considerably in a longer time experiment. In the course of these experiments, specific gravity of the natural

sea water 1.017, pH 8.0 water temperature 26°–28°C., room temperature 27°–38°C. were observed.

Experiment 2: This experiment was conducted in the same manner as the previous one, but longer time intervals were used. The results are shown in Table II.

Table II. The influence of diluted sea water on the heart beat for longer period. (Water temperature 26°C.)

No.	Kind of sea water	Specific gravity	Numbers of heart beat	Hight of amplitude	Remarks
1.	Normal sea water	1.0160	17–19	8 mm.	For 20 min.
2.	1/4 diluted sea water	1.0030	20–17–13	7 〃	Gradually became irregular for 20 min.
3.	Normal sea water	1.0175	13–20–18	5 〃	For 10 min.
4.	1/5 diluted sea water	1.0025	Irregular 9–3–2	7–3 〃	Decreased activity.
5.	Normal sea water	1.0175	20 after 5 min.	Gradually recover	Irregular at fist.

These experiments were carried out in order from No. 1 to No. 5 as were those of Table I. As will be seen from Table II, it is supposed that the heart activity remarkably decreased in 1/4 diluted sea water and might not be able to survive for a long time.

Experiment 3: This experiment was undertaken to determine the safe limit of the dilution of sea water which the heart could stand and the data of the experimental results are shown in Table III.

Table III. Showing the limit of the possibility for the heart beat (from No. 1 to No. 4) in various dilutions of sea water. (Water temperature 26°C.)

No.	Kind of sea water	Specific gravity	Remarks
1.	Natural sea water	1.0172	
2.	1/4 diluted sea water	1.0040	Became feeble gradually.
3.	1/5 〃	1.0025	Became feeble soon.
4.	1/6 〃	Not clearly. (Could not observed by hydrometer.)	Became feeble rapidly.

The data of this table suggests that the safe limit for the dilution of the sea water in which the heart beat retaines suitable activity is that of water near a specific gravity of 1.0040, or diluted to about one fourth natural concentration, because the heart beat activity was seen to decrease gradually seen in such diluted water.

Experiment 4: As a check on the previous experiment, this experiment

was repeated and the data are shown in Table IV. The temperature and specific gravity at the time of this experiment were lower as the result of rainfall in the previous night: Water temperature 25.5°C. sp. gr. 1.0145.

Table IV. On the relation between heart beat and the dilution of sea water. (Water temperature 25.5°C.)

No.	Kind of sea water	Specific gravity	Remarks
1.	Normal sea water	1.0145	
2.	1/3 diluted sea water	1.0035	Decreased activity and became irregular after 20 min.
3.	1/4 〃	1.0025	Remarkable decrement.

The result of this experiment indicated that the heart beat decreased remarkably in the diluted sea water of the specific gravity of 1.0035 which value corresponds to the result in Table III mentioned above.

Experiment 5: This was also done for the sake of ascertaining more exactly the results of the previous data (Water temperature 27.5°C.)

Table V. Relation between heart beat activity and the dilution of sea water at 27.5°C.

No.	Kind of sea water	Specific gravity	Remarks
1.	Normal sea water	1.0160	Pulsation 13 per 1 min., amplitude 10 mm.
2.	1/2 diluted sea water	1.0070	Pulsation 12–10 per 1 min., amplitude 12 mm.
3.	1/3 〃	1.0040	Gradually became irregular.

The heart beat was extremly regular in the diluted sea water of 1.0040 sp. gr., however 10 minutes after being placed in this diluted sea water it gradually became irregular. The experiment in the 1.0040 sp. gr. was started at p.m. on August 7, 1952 and the observations were continued until 7 p.m. at which time the heart beat had become irregular and feeble. The experiment was left over night and at 9 a.m. the next morning it was found that the beat had stopped beating.

In this experiment the sample was commonly set in 200 cc. of diluted sea water, before leaving the experiment at 7 p.m. it was put into 3000 cc. of sea water so that such influences as oxygen depletion and accumulation of excretion could be fairly well discounted, and therefore, it may be concluded that the death of the animal in diluted sea water was caused by the hypotonic osmotic pressure indicated by lower specific gravity.

From the data of this experiment it is concluded that the heart could live at least from five to six hours in diluted sea water of 1.0040 sp. gr..

Experiment 6: In this experiment the test material was placed in 500 cc. of sea water diluted with distilled water to a sp. gr. of 1.0050 at 12h45', after recording the normal curve in natural sea water of 1.0200 sp. gr., water temperature 21°C..

The heart beat was from seven to eight in thirty seconds and it gradually became irregular. At about 13h45' it was observed that the heart would beat once or two times in succession followed by a lapse of from ten to fifteen seconds (Plate I, Experiment A–1, A–2).

At the time of 15h40' (Exp. A–3), the peak rhythm had disappeared and only faint motion was seen somewhat regularly. The tone began to relax generally at this condition and the curve of the heart rhythm went down below the base line (A–4), the motion became feeble and the period of the rhythm increased more and more (A–5).

At five o'clock in the next morning, period extended from one minute to one minute and a half (A–9), and the pulsations were too feeble to be recorded by kymograph and at last the heart beat stopped completely at 14 o'clock.

Then diluted sea water of this experiment was changed to natural sea water (specific gravity 1.0202, water, temperature 21°C.); but, the heart beat did not recover even at 15 o'clock (Plate II, Exp. A–18).

From this experiment, it was concluded that the pulsation of the heart could continue at least for twenty six hours at the temperature between 16°–21°C., in diluted sea water at specific gravity of 1.0050, and such heart could not recover its activity even if it was transferred to the natural sea water (Exp. A–18).

Experiment 7 and 8: The pulsation of the heart stopped after thirty minutes in the 7th experiment and seventy minutes in the 8th one, when the natural sea water was changed to the sea water of 1.0030 sp. gr. at 21°C. But, at the time when the diluted water was changed back to the natural sea water, the activities of the two materials began to appear again. From this experiment, the heart of the pearl oyster could recover even when it was stopped after about one hour in the water of sp. gr. 1.0030.

Experiment 9: The rate of heart pulsation which was twenty-six beats per minute, 3 mm. amplitude, in natural sea water of 1.0170 sp. gr. at 21°C changed gradually from thirty-two beats per min., 12mm. amplitude; to twenty-two beats per min., 3 mm. amplitude; to fourteen beats per min., 5 mm. amplitude, and after seven hours to fifteen beats per min. 10 mm. amplitude, when diluted sea water of 1.0070 sp. gr. at 21°C (one half concentration) was used.

The next morning, after eleven hours in the same water of 1.0070 sp. gr., the heart beat was still observed although it was very feeble. However the heart recovered its activity when the diluted water was changed to the natural sea water.

When the results of the first nine experiment are summarized, the following conclusions will be given:

(1). The heart pulsations soon decreased and stopped within about one hour when the natural sea water was changed to the diluted sea water of specific gravity 1.0030, as is seen in experiments 2, 7 and 8.

(2). In the experiments with specific gravity 1.0040, as were done in the experiments 3 and 5, the heart beat continued for about five to six hours.

(3). In the experiment with specific gravity 1.0050, as was shown in 6th experiment, the heart pulsation was observed for twenty-six hours after the water was changed.

(4). In the 9th experiment, in which specific gravity was 1.0070, the heart beat stopped after 23 hours, however it recovered its activity when the diluted sea water was changed to the natural sea water and at that time the water temperature was twenty-six to twenty-seven degrees Centigrade.

(b) On the relation between salinity and the living activities of the individual shells

The influences of various salinities on the body of the pearl oyster have been studied, while, only the effect on heart beat in such conditions were observed in the studies explained in the previous chapter.

Three concentrations of sea water, one liter of each, with specific gravities of 1.0030, 1.0050 and 1.0070, were prepared in two liter size glass beakers. In each of them, two pearl oysters of almost equal size of three years old were set quietly, and observation was made to see the time when the shells opened due to loss of ability to remain closed.

From the results of the previous heart beat experiments, it was supposed that the shells which were in the diluted sea water of sp. gr. 1.0030 would lose their closing abilities quickly, and the ones in the sp. gr. of 1.0070 would be remain closed to the last. But, by the results of experiments showed the contrary to be true. The shells in the sp. gr. of 1.0070 opened their shells first, 39 hours after putting them into the sea water of 19°–21°C. in temperature, and after 45 hours in the same specific gravity water of 11°–13°C., while all the other ones in the specific gravity of 1.0050 and 1.0030 maintained their closing abilities and did not open their shells.

At that time, the mantle margins of the ones which opened in 1.0070 sp. gr. did not react to mechanical stimulation and, even, the mantles of the remaining shells, which did not open, also did not react to the same stimulus when opened by force with an opening apparatus.

But, when the diluted sea waters of 1.0050 and 1.0030 sp. gr. were changed for natural sea water, all the shells in those diluted sea waters completely reco-

vered their activity after 24–30 hours respectively, and the ones in the water of 1.0070, sp. gr. did not recover at length.

(c) On the freezing point depression of the body fluid of pearl oyster in the diluted sea waters

In this chapter, the present writers have studied the effect of diluted sea waters on the body fluids of pearl oysters and observed how the freezing point depressions of their fluids change in the various sea water by using Beckmann's thermometer.

Natural and diluted sea waters and body fluids extracted through gauze from finely macerated bodies of pearl oysters from various concentrations of sea water were employed as experimental materials.

The freezing point "Δ" of various kinds of sea waters are shown in Table VI.

Table VI. Freezing point depressions of the various sea waters.

Specific gravity of d. s. w. (σ_{15})	1.0030	1.0050	1.0070	1.0230
$\Delta\vartheta f$	−0.231	−0.369	−0.533	−1.884
	−0.232	−0.373	−0.530	−1.901
	−0.230	−0.371	−0.528	−1.860
	−0.226	−0.370	−0.532	−1.890
Average	−0.229	−0.371	−0.531	−1.840

The values of "Δ" of extracted body fluids of pearl oysters which were living in the natural sea water of specific gravity of 1.0230, pH 8.4, water and in the various concentrations of diluted sea water were measured and are shown

Table VII. "Δ" values of extracted body fluids of pearl oyster in the various concentration of sea water.

Conditions	$\Delta\vartheta f$	Average
The ones in the natural sea water, sp. gr. 1.0230	−1.898 −1.987 −1.989 −1.900	−1.944
The ones which opened their shells after 47 hours in the sea water of sp. gr., 1.0070	−1.067 −1.067 −1.062 −1.066	−1.066
The ones which did not open their shells in spite of being in the sea water of sp. gr., 1.0030 for 47 hours.	−1.667 −1.667 −1.659 −1.661	−1.664
The ones which were kept open with wedges after being opened by the opening apparatus and put into the sea water of sp. gr., 1.0030 for 2 hours.	−1.117 −1.122 −1.120 −1.121	−1.120

in Table VII.

The results of these two tables are shown graphically in the Fig. 2. In this figure, the data in Table VI form a straight since freezing point lowering is directly proportional to the concentration in such dilute solutions.

In comparing the data of Tables VI and VII, it is observed that the Δ values of the extracted body fluids of pearl oysters in the natural sea water are almost coinsided with the Δ of the sea water and this fact is always seen in the body fluids of marine invertebrata as A. Krogh (1939) described. The values of

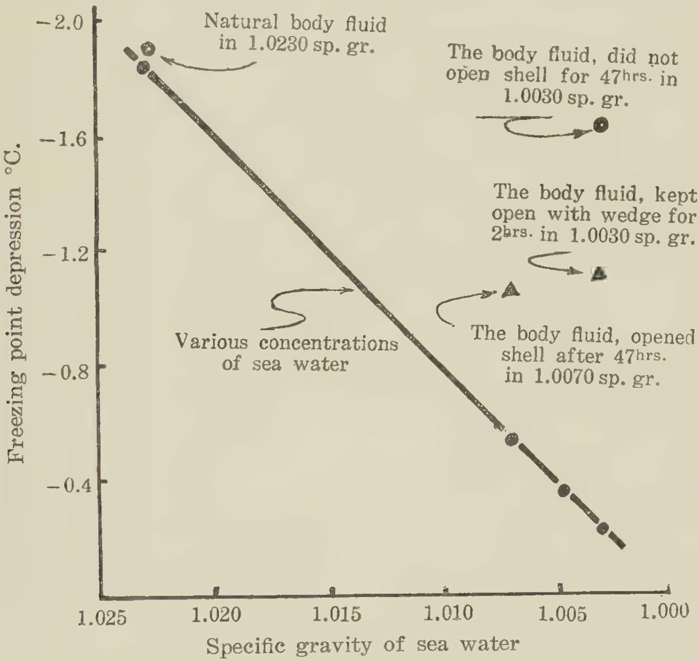


Fig. 2. Showing the change of the "Δ" values of extracted body fluid of pearl oyster in the various concentrations of sea waters, and the values of the "Δ" of the various sea waters.

Δ of the pearl oyster that remained closed differed slightly from the data of Δ of the natural sea water in which the shells had been laid, while the Δ data of those shells which opened, lowered considerably as will be seen in Fig. 2.

Conclusion

From the results of the experiments which were described in chapter (a), it was concluded that the heart beat activity of the pearl oyster decreased gradually as the natural sea water was diluted and at a specific gravity of 1.0030 the heart beat activity decreased very rapidly.

The writers confirmed that the heart beat continued over twenty-six hours in the waters with specific gravity of 1.0050.

But, the facts are quite different in the experimental results of chapter (b), the shells which were in the more concentrated sea water (sp. gr. 1.0070) opened first, and the ones in the less concentrated sea water of sp. gr. 1.0050 or 1.0030 never opened their shells in the course of the experiments.

By the previous experiments, it can be concluded that the results of chapter (a) showed the activity of heart beat largely influenced in the various concentrations of the enviromental sea waters as the heart directly contacted with the waters, while the results of chapter (b) indicated that the influence of diluted sea waters on the individual of pearl oyster is comparatively small as the shells warp tightly their body at the time of unfavorable environmental condition.

We concluded that the pearl oysters in the sea water of 1.0070 sp. gr. open their shells and will be injured without knowing the influence of low osmotic pressure as the stimulation of such diluted sea water may be comparatively small, but the shells which are suddenly put into the more diluted concentrations of the sea water avoid injuries and be alived by closing their shells tightly as the stimulation of those very diluted sea waters to the shell may be severe.

The effect of rainfall on the pearl oyster in the farm must also be considered. As the sea water is slowly diluted by and extended rainfall, the dilution of the sea water gradually but surely influenced the shells and may be affected them into the death without any stimulation of the change of diluted concentration of the sea water.

Therefore the data in the experiments of chapter (b) should be applied, instead of those of chapter (a), when considering the influence on the heart beat of the dilution of sea water during and extended rainfall. Also it was concluded that the pearl culture technicians ought to exercise particular caution whenever the specific gravity of the water falls below 1.0070 of sp. gr. by the rain as the shells might be in danger of dying after 24 hours in such water, and the writers consider that the shells may be able to alive at least in 39 hours even in such rainfall by closing the shells by means of some stimulation method to them.

Acknowledgments

The authors wish to thank the following who have extended aid during these investigations: Mr. K. Shimamura, owner of the Shimamura Pearl Farm, and T. Komaki, Director of that farm; Mr. K. Isowa, owner of the Nippon Pearl Farm Ltd., for the use of the facilities of their laboratories; Dr. Y. Matsui, President of the Nippon Institute for Scientific Research on Pearls, for kind suggestions.

Literature

KROGH, A.: Osmotic regulation in aquatic animals. 1939. Cambridge.

Plates I–II

Explanations of the Plates I and II.

Showing the results of the experiment on the duration of time of the heart beat ability in the diluted sea water 1.0050 of sp. gr., at 21°C..

Exp. A–1. Natural sea water 1.020 of sp. gr. diluted sea water 1.005 of sp. gr..

Exp. A–2. The heart would beat once or two times in succession followed by a lapse of from ten to fifth seconds.

Exp. A–3. The peak rhythm had disappeared.

Exp. A–4. The tone of the heart beat began to relax.

Exp. A–5, A–6, A–8. The motion became feeble.

Exp. A–9. The period of beat extended.

Exp. A–12, A–13, A–14. The pulsations were too feeble to be recorded.

Exp. A–15. The diluted sea water was changed to natural sea water.

Exp. A–16, A–17, A–18. But the beat did not recover.

PLATE I

Exp. A-1

Exp. A-2

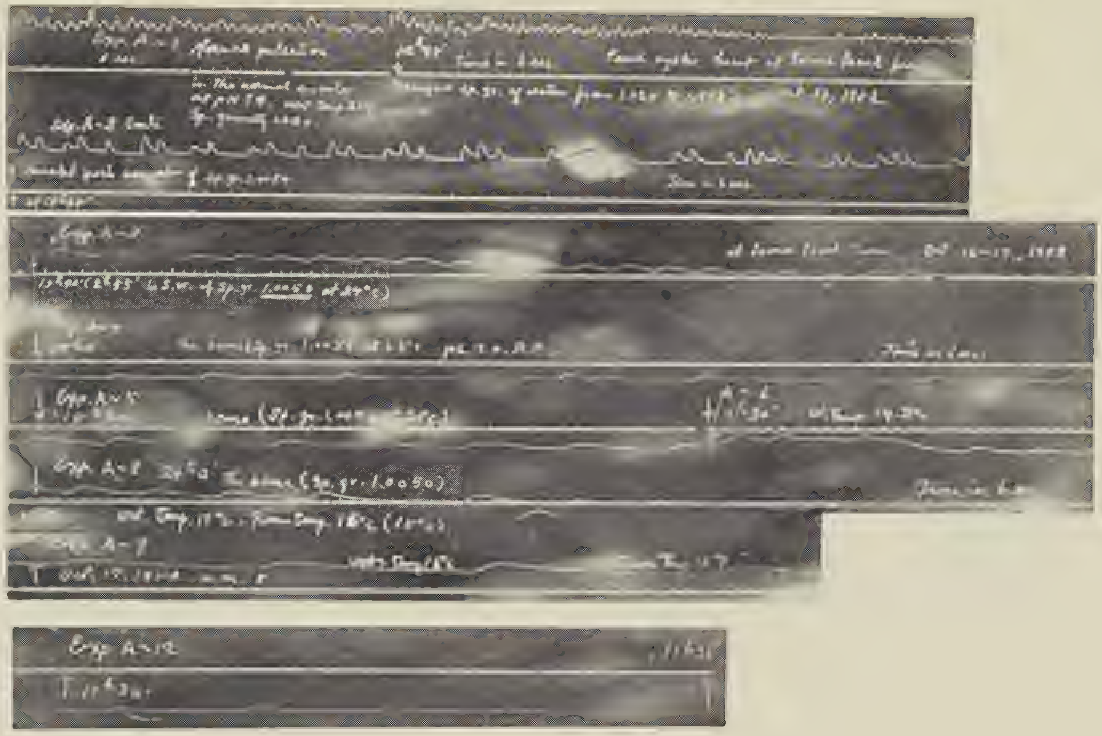
Exp. A-3

Exp. A-4

Exp. A-5

Exp. A-9

Exp. A-12



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Exp. A-13

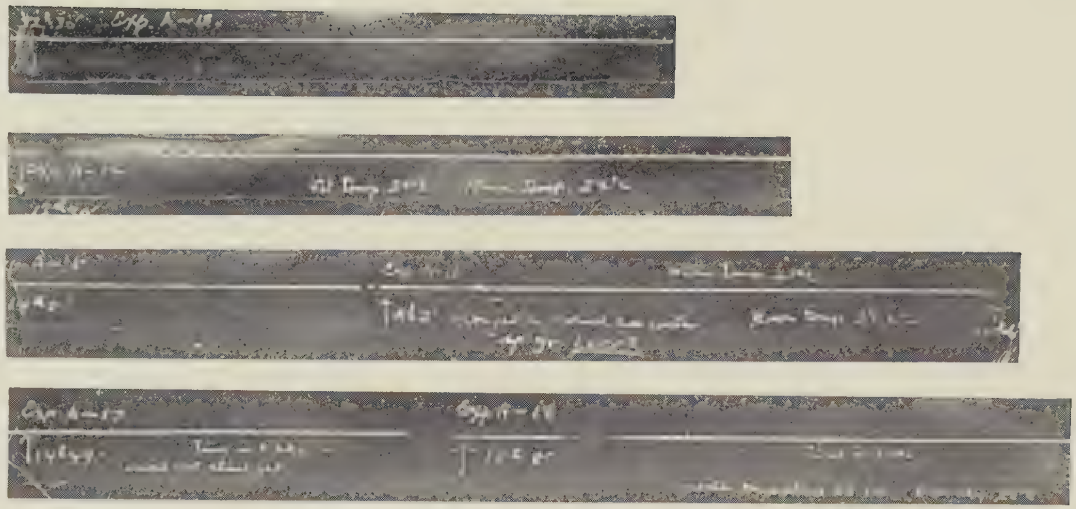
Exp. A-14

Exp. A-15

Exp. A-16

Exp. A-17

Exp. A-18



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Vol. 1, No. 3, July 30, 1954.

Studies on the Influence of the Moonlight upon Efficiency of the Fish Lamp

(*With 7 Text-figures*)

N. Y. KAWAMOTO and K. UNO
Faculty of Fisheries, Prefectural University of Mie

The efficiency of the fish lamp in the field of the moonlight has been generally discussed by many fishermen, however no scientific research about this matter has been done up to this time. Dr. SIDNEY C. HSIAO did not discuss on the influence of the moonlight, although he studied (1952) valuable experiment on the reaction of Tuna to artificial light in the tank which Prof. A. L. TESTER has reported (1952).

Therefore, the present writers have studied to clear up this relation. First, laboratory work for this study was carried out, and then open sea experiments were undertaken in the sea near the coast of the Ichthyological Research Institute at Shimoda, Izu Peninsula, Japan.

Materials employed

The fishes which were employed as experimental materials in the laboratory were collected in the sea around the Institute and raised in the aquarium in our laboratory. The materials used are listed in Table 1.

Table 1 Names and body lengths of fishes used.

Name	Body length
Pempheris japonica D.	28–34 mm.
Girella punctata G.	26–31 〃
Spheroides niphobles J. et S.	25–31 〃

Experiment

I. Laboratory experiment

Method: A round wooden tank 1 m. in diameter, 25 cm. in height was used as the experimental aquarium. A 20 watt electric bulb, called F light, representing the fish lamp, was immersed into the water near the side of the tank and the bulb adjusted so as to throw its light horizontally in one direction.

Another electric bulb, called M light, representing the moon, was suspended 2 m. above the center of the water surface and its luminosity adjusted to 0.068 lux on the water surface by regulating the light with a screen. The value of

the luminosity above mentioned was determined from the luminosity of the full moon on the sea surface which was measured to be from 0.06 to 0.07 lux at the time of the full moon night. These luminosities were observed by the photo-electric luxmeter made by Science Research Institute (Rikagaku Kenkyu Jō) and the sensitivity of that machine was 10^{-4} lux.

For the study of the influence of colors, Mazda glass filters were employed.

In each experiment, ten fish were set free in the tank and enumeration of the numbers of fish gathered in the light field was made by turning on the two bulbs simultaneously after allowing the fish to adapt themselves to the darkness for thirty minutes. The influence of the M light was judged by comparing the number of fish gathered in the field of the F light when the M light was off with the number gathered in the light field of the F light when the M light was turned on.

Results of experiment: *Pempheris japonica* and *Girella punctata* were employed in these experiments at temperature 13°–14° C., and the results are shown in Table 2 and Figs. 1 and 2, as follows.

Table 2. Influence of one light on the fish gathering rates in the field of another light representing a fish lamp.

No.	M-light min.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	average
Girel.	off	18.7	28.7	15.0	23.7	22.5	23.7	36.2	36.2	32.5	33.7	32.5	35.0	26.0	30.0	25.0	27.8
	on	17.5	20.4	25.6	24.4	24.4	25.6	20.0	25.6	25.0	21.9	28.8	30.3	31.2	27.5	35.5	25.6
Pemp.	off	20.8	40.0	45.0	44.2	34.4	29.2	29.2	27.5	26.7	25.0	28.4	26.7	25.0	25.0	23.3	30.0
	on	8.3	16.7	18.3	17.5	21.6	18.6	17.5	23.3	19.3	17.5	16.7	20.0	20.8	20.0	18.6	18.3

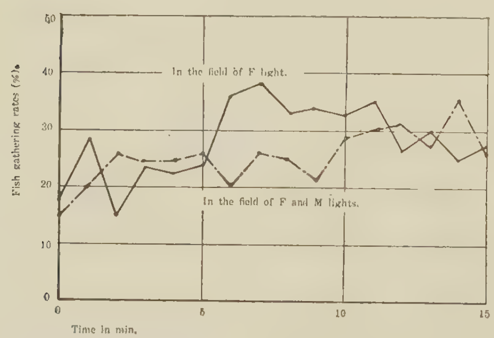


Fig. 1. Showing the differences between fish gathering rates of *Girella punctata* in the fields of one light (F light) and two lights (F and M lights).

It was observed that there are differences between these two Figs. when comparing the curves of gathering rates of the two species of fishes. The two curves in the experiments of *Girella* almost coincided with each other although some differences were observed (Fig. 1.) while remarkable differences were seen in the results with *Pempheris* (Fig. 2.). The rates of gathering of *Pempheris* in the field of F light alone were higher than in the field of F and M lights together, especially in the course of the first two to three minutes.

Therefore it can be generally considered that differences in the gathering rates of fishes do exist in the different kinds of fishes.

For determing the influences of the various kinds of luminosities and colors, the distance from the surface of the water of M light, representing the moon, was varied, and color filters of green, red and white were used on the F light which represented the fish lamp.

As color filters, white No. 44, green No. 27 and red No. 24, which were made by Mazda Co., were employed in this experiment, and their transparency characteristics were examined with a E. G. spectrophotometer.

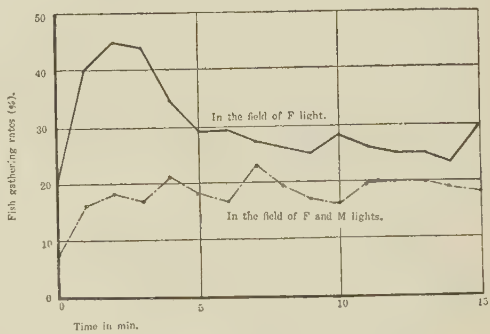


Fig. 2. Showing the differences between fish gathering rates of *Pempheris japonica* in the fields of one light (F light) and two lights (F and M lights).

Table 3. Showing changes of fish gathering rates influenced by various colors of F lamp (*Spheroides niphobles*).

Luminosities of M lamp (lux)		0.000	0.019	0.0395	0.049	0.076	0.093
Lights of F lamp	White light	59.1%	33.2%	17.3%	16.0%	8.4%	3.7%
	Green 〃	51.5	40.2	32.7	28.9	22.1	10.9
	Red 〃	50.8	14.3	4.3	—	—	—

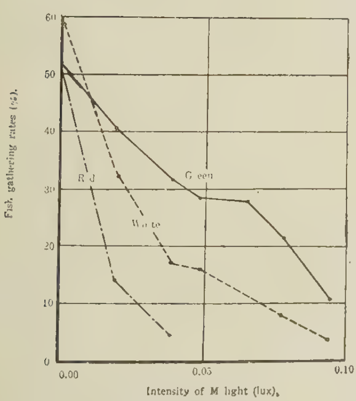


Fig. 3. On the influence of M light on the rates of gathering in the field of various colors of F light (*Spheroides niphobles* J. et S.).

These data are shown in Fig. 3 and from these results it was observed that as the luminosity of M lamp increased, the gathering rates decreased. It can also be concluded that the influence of the M light is very significant.

The rate of decrease is the largest in the field of red color and the least in that of green, in other words, it might be said that the green color of F light had the largest power of efficiencies as fish lamp, at least among these three colors.

Consideration: From these experiments with M and F lights, it appears that the light of the full moon must affect the fish gathering rates in the field of the fish lamp, as the luminosities of the full moon ranged

from 0.06 to 0.07 lux which was just like that of the M light.

The present studies were considered to be a special case of Kawamoto and Konishi's experiments with two lamps (1952) because two sources of light, M and F lamps, were used.

But in this case, only the difference was that the field of M light spread over the field of F and M lights throw light all over the surface of the experimental water, while in Kawamoto and Konishi's experiment the fields of the two lamps were separated and the remaining part in the water beyond those two fields was dark.

Therefore, the relation between gathering rate and spectral luminosity ought to be discussed for the same reason as this is a special case of the two lamps.

II. Open sea experiments

All previous experiments, which were carried out in the laboratories and therefore show only the relationship between light and fish behavior, differed from that of the relationship between the fish lamp and fishes in the open sea where many other factors, such as the moonlight, direction of current, winds, tidal movements, temperature, etc., will also affect the gathering rates of the fish.

For the study of the open sea experiments, a rectangular net was set 200 meters off the coast near the laboratory of the Ichthyological Research Institute.

The experiment was performed during winter because of certain circumstances, and not a few difficulties were experienced from the rough seas because the weather was frequently stormy during the experiments, and at last the net was swept away by the storm on the night of 14th of February in the year of 1950 and the study had to stop.

Therefore the experiment is not as complete as the authors have expected to make them, but the remainder of the study will be carried out at some later days.

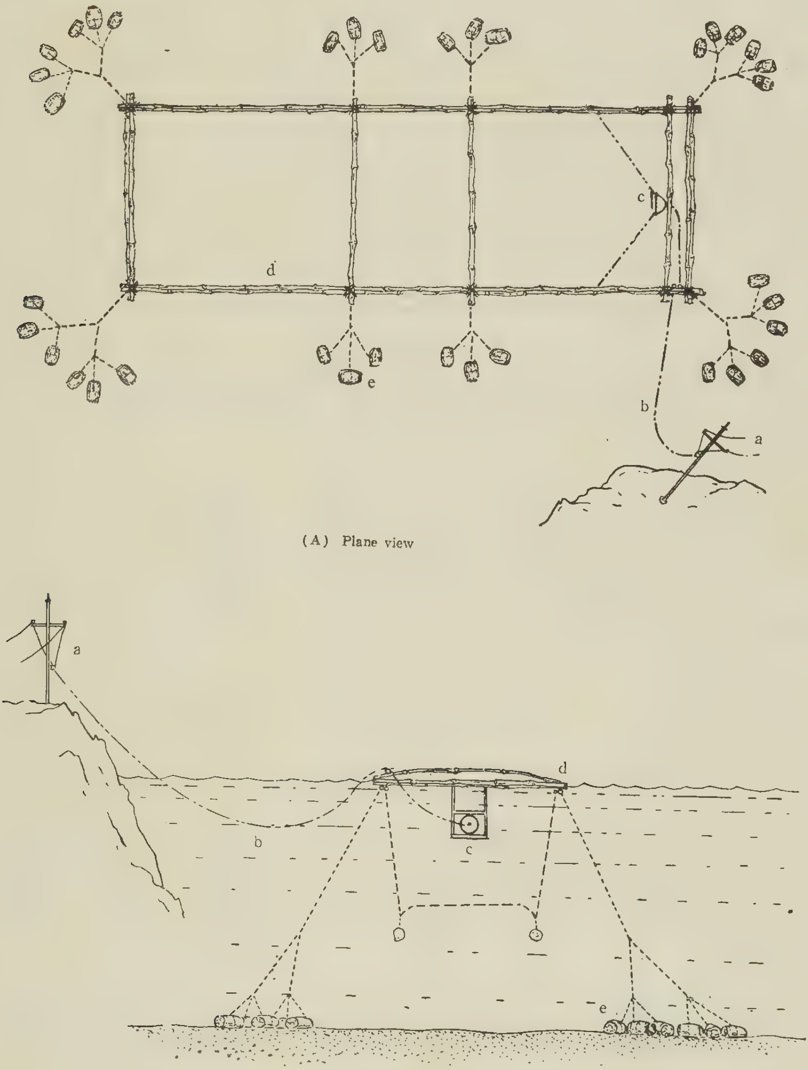
Method of experiment: Adult horse-mackerels *Thrachurus trachurus* L. 16.2 cm. in average body length and 29.8 gm. in average weight, which were fished off the coast of Shimoda near our laboratory were kept in the fish-preserve net in the sea.

Small pieces of other fish meat were given to them as food at 15 o'clock every day. These fish were used as experimental materials after being kept in the net for a week.

The rectangular net, which was 3 m. deep, 20 m. long, and 6 m. wide and made of 1.8 cm. mesh, 12 thread cotton yarn, was suspended from a bamboo float which was fixed in the sea by many anchors which consisted of straw bags

filled with sand as shown in Fig. 4. A and B.

One end of that net, a fish lamp was fixed under 1 m. from the water surface and it was connected by captire cord with electricity from the laboratory.



(A) Plane view

(B) Side view

Fig. 4. Diagram of the rectangular net.

a. electric cable. b. captire cord. c. fish lamp.
d. bamboo float. e. straw bags filled with sand.

As a source of light, 20 W, 60 W. and 100 W. electric bulbs were used and a green glass filter 18 cm. in diameter made by Science Research Institute was adopted.

Because of the geographical situation of that coast, it was impossible to

conduct the experiment at the time for east and northeasterly winds due to the extreme roughness of the sea, and hence all experiments were conducted at the time of westerly winds when the sea was comparatively calm.

Ten experimental fish were set free into the rectangular net at least one hour before sun set, and the study was done during three hours in the night near the time of low tide. For the sake of studying the relation between the luminosity of the moon at various ages and the strength of fish light used, 20 W., 60 W., and 100 W. electric light bulbs were each tested for several different ages of the moon. The gathering rates were computed from the number of fish gathered within 3.5 meters of the submerged light. On the other hand, the luminosities of the moon light on the surface of the sea were observed at nearly median time of each moon age and the water temperature was 14.0°–15.5° C. during the experiments.

Results of experiments: The luminosities at various distances from the source of light in the water were measured by a photoelectric luxmeter as shown in Table 4.

Table 4. Luminosities of fish lamp at various distances from the source of light in the sea water.

Distance \ Source of light	20 W.	60 W.	100 W.
1.5 m.	0.090 lux	— lux	— lux
3.5 〃	0.034 〃	0.047 〃	0.062 〃
8.0 〃	0.007 〃	— 〃	— 〃
10.0 〃	0.001 〃	0.007 〃	0.012 〃

The luminosities of moonlight at the median time on the surface of sea water were observed and those of light 2 m. under the surface were calculated from the data by using absorption coefficient of sea water as -0.619/m. as follows (Table 5).

Table 5 Showing the luminosities of moonlight at various moon age on the surface of sea water and 2 meters layer under the water surface.

(lux)

Moon age	5.5	7.7	8.7	9.7	10.7	11.8	12.8	13.8	14.8	15.8	16.8	17.3	18.5	19.5
Surface of sea	0.001	0.006	0.010	0.015	0.017	0.023	0.030	0.042	0.064	0.058	0.040	0.036	0.021	0.014
2 m. under sea	~	0.002	0.003	0.004	0.005	0.007	0.009	0.012	0.019	0.017	0.012	0.010	0.006	0.004

The number of fish which entered into the light field of the fish lamp in the area within 3.5 meters from the source of light was recorded every thirty

Table 6 Showing comparison between conditions of gathering rates in the light field of 20 W. fish lamp at the times of 10.7 moon age and of moonless night.

(20 W.)

Time (min.)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0
Moonless n. (%)	0	0	0	23	85	90	85	85	100	90	83	93	93	72	68	80	52	55	80	83	70	90	90	80
Moon age 10.7 (%)	0	0	0	10	50	55	0	0	20	45	50	80	15	40	15	20	10	0	0	0	0	0	0	0

Table 7 Showing comparison between conditions of gathering rates in the light field of 60 W. fish lamp at the times of 14.8 moon age and of moonless night.

(60 W.)

Time (min.)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
Moonless n. (%)	0	26	100	56	56	23	100	60	26	70	80	0	23	53	60	10	26	83	60	73
Moon age 14.8 (%)	0	80	50	0	0	0	0	0	0	60	40	0	0	0	0	0	0	0	0	0

Table 8 Showing comparison between conditions of gathering rates in the light field of 100 W. fish lamp at the times of 17.8 moon age and of moonless night.

(100 W.)

Time (min.)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
Moonless n. (%)	0	0	100	0	100	0	0	0	100	100	0	0	90	0	85	0	80	0	65	45
Moon age 17.8 (%)	0	0	100	90	95	0	45	0	0	100	100	0	100	65	80	45	0	80	0	70

seconds from the time of turning on the light for twenty minutes. The gathering rates were converted into percentage from the data above mentioned, and the results were shown in Tables 6, 7 and 8.

The data of these three tables are graphically shown in Figs. 5, 6 and 7.

It is clearly shown that the gathering rate decreases as the moon age increases to the full moon and the increase in gathering rate was comparatively larger for stronger fish lamp in spite of gathering form was very irregular even in moonlight condition. Therefore, the rates of gathering was almost equal on both the dark night and in the 17.8 moon age when 100W. electric bulb was used as a fish lamp, as will be seen in Fig. 7.

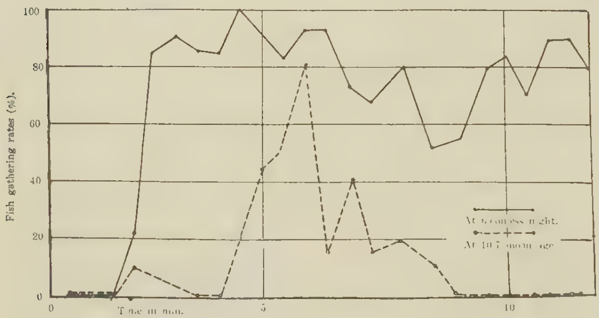


Fig. 5. Comparison between gathering rates in the light field of 20 W. electric bulb at the times of 10.7 moon age and moonless night.

In comparing the moonless night data in the Figs. 5, 6 and 7, it is shown that the gathering rate for the fish lamp differed in accordance with the wattage of the electric bulbs used. In the case of the 20W. bulb the rate was comparatively stable as the curve was horizontal after 2 minutes and thirty seconds turning on the light, while the rate of gathering became quite irregular in the case of higher wattage bulbs. This might indicate that the higher wattage bulbs produced too intense a light for fish on a moonless night in the limited area of this rectangular net.

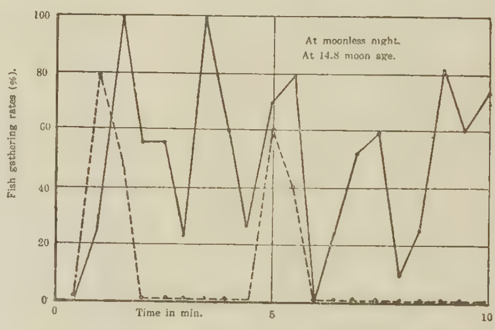


Fig. 6. Comparison between gathering rates in the light field of 40 W. electric bulb at the times of 14.8 moon age and moonless night.

The writers compared the influence at the times of various moon ages on the fish gathering rates of 20W., 60 W. and 100 W. fish lamps respectively as in Table 9.

It will be seen from Table 9, in the case of the 20 W. bulb fish lamp with green filter, the fish gathering rate to the field of this light on the night of 9.8 moon age decreased to 77.8% in comparison with that of the moonless night, and decreased to 21% at 10.7 moon age.

The rate reaches zero at 11.8 moon age and showed no reaction to the

fish lamp. It was considered that the nonreaction to the fish light would continue during the period from 11.8 to 18.0 moon age, because the luminosities of moonlight in that period were higher than that of the 11.8 moon age.

On the moonless night, the gathering rate was quite stable at the fish lamp of 20 W, while the rates were comparatively irregular at 60 W and at 100 W respectively as mentioned above (Figs. 5, 6 and 7). Therefore it could be said that the fish lamp of 20 W was adequate with in the limit of this experimental net for mackerels on a dark night.

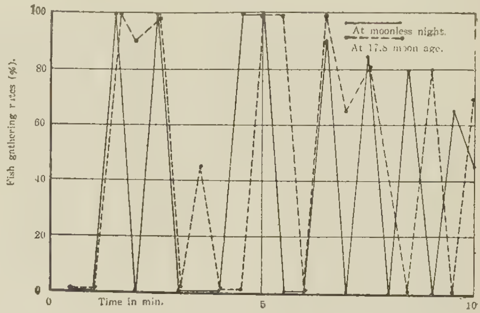


Fig. 7. Comparison between gathering rates in the light field of 100 W. electric bulb at the times of 17.8 moon age and moonless night.

The fish gathering rate to 60 W fish lamp in the 12.8 moon age decreased to 45.9% in comparison with that on the moonless night and also decreased to 19.2% at the moon age from 13.8 to 14.8. The gathering rates were extremly irregular during the period 12.8–17.8 moon age.

Table 9 Showing the relationship between fish gathering rates at the various moon ages and at 20, 60 and 100 W fish lamps.

	20 W (Green filter)						60 W (Green filter)						100 W (Green filter)	
Moon age	9.8	10.7	11.8	12.8	24.3	Moon-less	12.8	13.8	14.8	16.0	15.8 (Current)	Moon-less n.	17.8	Moon-less n.
F. G. Rate, %	77.8	21.0	0.0	2.1	59.3	63.3	45.9	19.2	0.0	0.0	32.3	52.4	51.6	49.1

The gathering rate to the 100 W fish lamp was higher at the 17.8 moon age than on the moonless night, although the conditions of gathering were very irregular, and from this result, it might be considered that the fish will be gathered even on the full moon night.

Conclusion

In conclusion, it was shown that the gathering rate to the fish lamp decreased when the ratio of luminosities of the fish lamp and the moonlight decreased to a certain value, and it was turned out that horse-mackerels will gather at the fish lamp to a certain limit even on a light night when the proper luminosity of fish light is used, and that this result will be applied also to young marine fishes.

The authors wish to thank Professor Doctor K. Matsubara who has kindly extended aid during this investigation.

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Report of Faculty of Fisheries,
Prefectural University of Mie,
Vol. 1, No. 3, July 30, 1954.

The New Species of Herposiphonia from Japan

(With 1 Plate and 4 Text-figures)

Toshio SEGI
Faculty of Fisheries, Prefectural University of Mie

For some years the writer has been studying the marine algae from the central Pacific coast of Japan. Among them there are some interesting ones. The present paper deals with the systematic description and note of a new species of *Herposiphonia.*

Herposiphonia terminalis spec. nov.

Plate 1 and Text-figs. 1–4

Syn. *Herposiphonia tenella* (non Naegeli) Okamura, Nippon Kaisō Shi (1936) p. 870; Id., Icon. Japan. Alg. vol. 6 (1930) pp. 23–25, pl. 264, figs. 1–9.



Plate 1. *Herposiphonia terminalis* n. sp. ×1.
Epiphytic on the leaves of *Zostera marina* Linnaeus.

Frons caespitosa, arachnoidea, nana, filiformis, unilateraliter ramosa, fere teres, saepe repens, epiphytica, rhizoideis ad aliam adfixa; rhizoideis longis et simplicibus, unicellularibus, 750-900μ longis, ca. 15μ crassis, ex geniculis in ventrali

fili primarii egredientibus ; filis primaris ca. 1.7–3.5 cm. longis, 60–70μ crassis, decumbentibus, radicantibus, decomposito-ramosis, ramisque pectinatis, apicibus curvatis introrsum et sursum ; ramis longioribus vel ramis brevioribus in dorsali eximie distinctis, uno per segmentum ; ramis longioribus dorsiventraliter constructis, multum ramosis, saepe degeneratis, apicibus involutis, distichis lateraliter et exogene ex geniculo quoque quarto emittentibus ; ramis brevioribus simplicibus, definitis, virgatis, gracilibus, 405–600μ longis, ca. 30μ crassis, alternatim ex

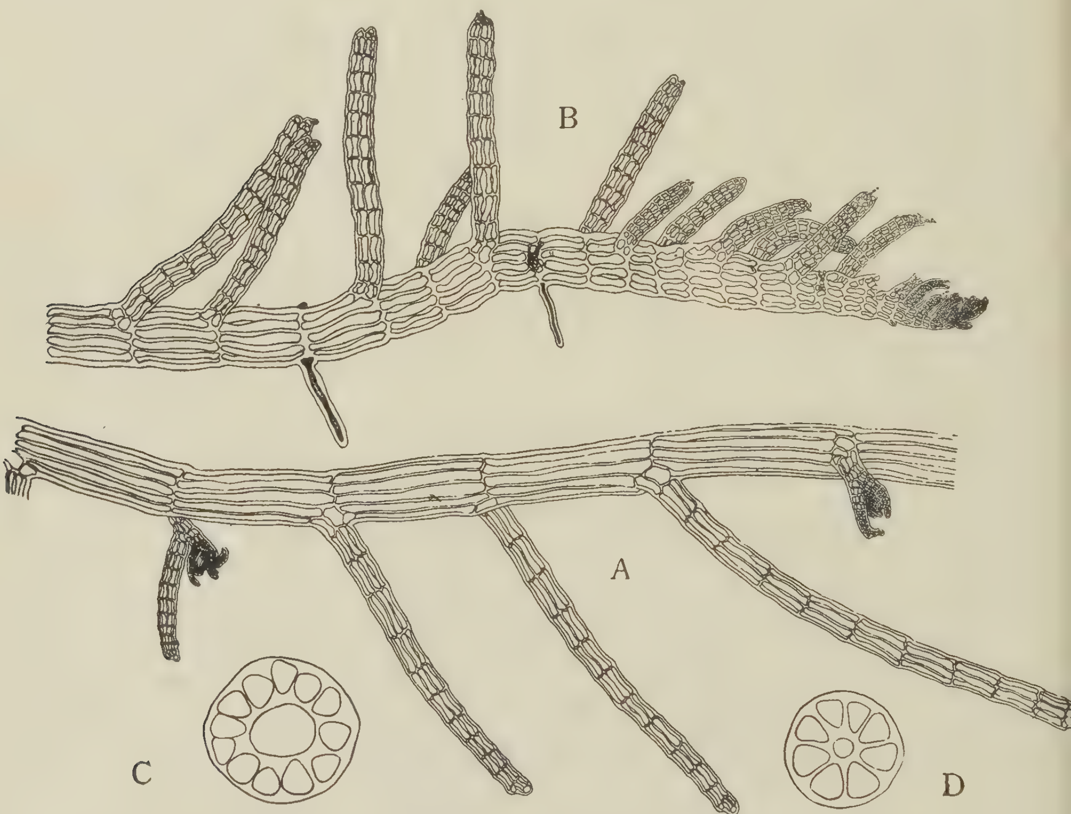


Fig. 1 *Herposiphonia terminalis* n. sp.

A. B. Primary filament showing the arrangement of the long and short branches (A: lower part, B: upper part). ×75.

C. D. Transverse section of the frond (C: lower part, D: upper part). ×310.

dorso bi-vel triseriatim exeuntibus, erectis vel ad apicem fili involutum parum incurvatis, apicibus obtusis ; trichoblastis 1–3 saepe ex apice ramorum longorum breviorumque emittentibus, uno per segmentum, continuis, spiram laevam facientibus, 1–3 furcatis, ca. 140–230μ longis, 12–17μ crassis, deciduis, elongatis, cicatricellulas inconspicuas relinquentibus ; articulis 8–12 siphonalibus, nudis, filis primariis inferioribus diametro 5-plo longioribus, mediis 2–3-plo longioribus, superioribus diametro fere aequalibus, in ramis 1–2-plo longioribus ; tetrasporangiis

3–7 in ramis brevioribus seriatis, continuis, verrucosis, prominentibus, globosis, ca. 60μ diam., tripartito divisis; procarpiis sparsis, ex segmento secundo trichoblasti apicis ramorum breviorum orientibus, fere parvis, ca. 40μ diam.; cystocarpiis ad ramos longos et breves robustos crassos terminalibus, solitariis, urceolatis, apicibus cervicibus et hiatis instructis, magnis, 390–570×600–825μ; antheridiis ignotis. Color fusco-roseus. Specimina exsiccatione chartae adhaerent.

Japanese name: *Kumonosu-himegoke.*

Hab.: Ikawatsu, Mikawa Prov.

Frond caespitose, arachnoid, dwarf, filiform, unilaterally branched, almost cylindrical often creeping, epiphytic, fixed to other alga by rhizoids; rhizoids long and simple, unicellular, 750–900μ long, about 15μ thick, arising from nodes on the ventral side of primary filament; primary filaments about 1.7–3.5 cm. long, 60–70μ thick, decumbent, radical, branched in decompound and in pectinate branches, incurvated inward and upward at apices; long branches or short branches distinct on the dorsal side, one per segment; long branches dorsiventrally constructed, much branched, often degenerate, involute at apices, distichous on the fourth node laterally and exogenously; short branches simple, definite, virgate, slender, 405–600μ long, about 30μ thick, alternately seriated in two-three rows on dorsal side, erect or slightly incurvated toward the inrolled apex of filament, obtuse at apices; trichoblasts 1–3 often emitted from the apex of long and short branches, one per segment, continuous, arising in a left hand spiral, 1–3 forked, about 140–230μ long, 12–17μ thick, deciduous, elongate, leaving inconspicuous scar-cells; articulations 8–12 siphoned, nude, 5 times as long as diam. at the lower part of the primary filament, 2–3 times at the middle, almost equal at the upper, 1–2 times in the branches; tetrasporangia 3–7 seriated in the short branches, continuous, verrucose, prominent, globose, about 60μ diam., tripartitedly divided; procarps sparse, arising from the second segment of the trichoblast in the apex of short branches, rather small, about 40μ diam.; cystocarps terminated on the long and thick short branches, solitary, urceolate, provided with neck and cleft on the apices, magnific, 390–570×600–825μ; antheridia unknown. Colour redish-brown. Specimens adhering to paper in drying.

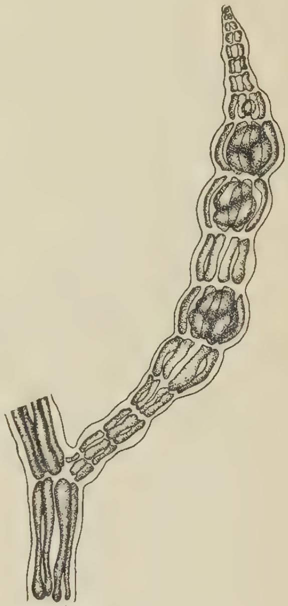


Fig. 2 *Herposiphonia terminalis* n. sp. Stichidium. ×94.

Along the Pacific coast of this locality the present material is found very abundantly growing on the leaves of Sea Phanerogams, *Zostera marina* LINNAEUS.

The writer collected a large number of specimens of this alga including some female ones.

In this species the frond is slightly torulose and composed of about 12 siphons in the lower part and 8 siphons in the upper part.

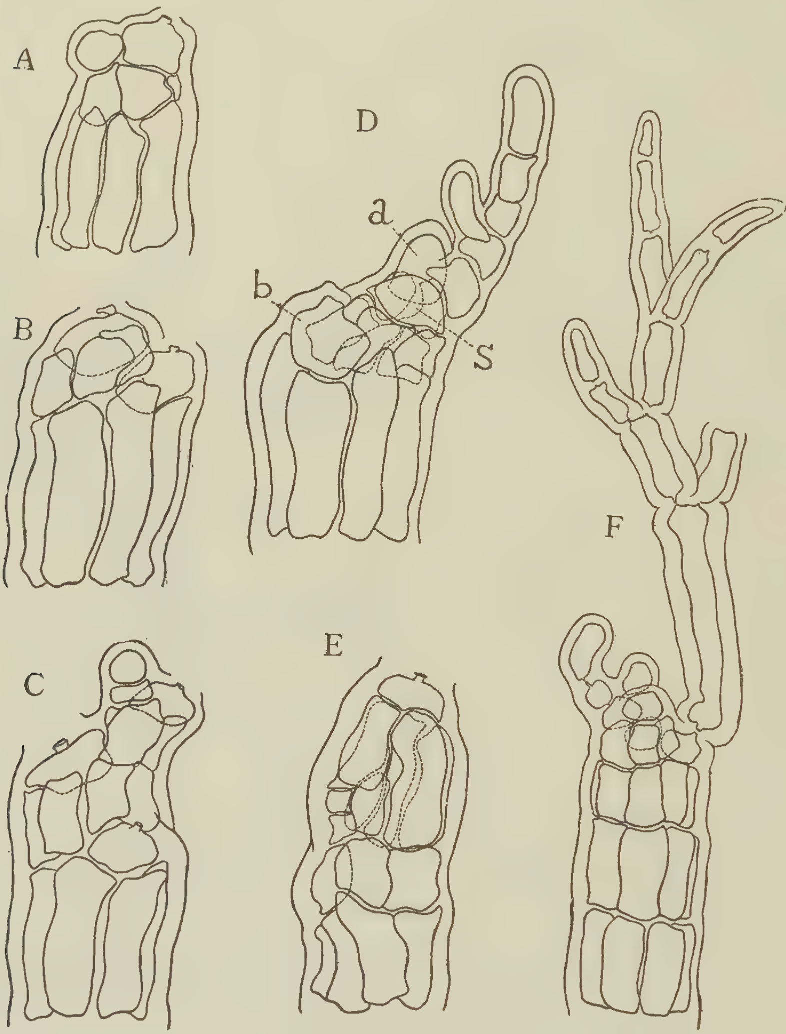


Fig. 3 *Herposiphonia terminalis* n. sp. Six tips of the short branches. A-E: ×600; E: ×400.
a: Apical cell of the branch. b: Basal cell of the trichoblast.
s: Scar-cell.

The trichoblasts are a few (1–3) developed only on the tip of a short or long branch. They occur one on each segment continuously in a spiral line running in a counter-clockwise direction towards the tip of the branch, when the branch is seen from the apex. It can be called as "Spiral*ling* to the left"

At the bases of them there are basal cells forming roundish lumps which are clearly distinguished from the pericentral cells. The trichoblasts are 1–3 forked, slender, gradually thicker towards the bases and 50–600μ (av. 230μ) long, 6–20μ thick in short branches. In long branches they are rather shorter, 30–250μ (av. 140μ) long and 8–22μ thick. Commonly they are deciduous and the basal cells remain as persistent scar-cells (cf. Fig. 3). The basal cells or scar-cells and apical cells are originated from central axial cells which are tokkuri (bottle)-shaped respectively.

The development of procarp can only be followed clearly in this material as noted below. The procarp arises on the second segment of the trichoblast which is developed only on the extreme top of the short branch. When the short branch attains to 9–11 segments, the trichoblast begins to arise on the top of it. Then the branch stops its growth at the tip. It seems that the topmost cell separated from central axial cell is divided in two longitudinally and the one of them develops to a trichoblast and the other remains as an apical cell (cf. Fig. 3, D). But often there are no apical cells at the tips. In such cases the basal cells emitting trichoblasts or scar-cells parted from trichoblast can only be observed instead of apical cells (cf. Fig. 3, B). At any rate the second segment of trichoblast with procarp starts a complex division. The first one is divided longitudinally into several pericentral cells. The basal cells also cannot be distinguished from pericentral cells of that part. When the procarps are developed, the cells of the third segments commonly are formed as if they were squeezed and remain in the top of them. The segments more than fourth ones are usually dropped off (cf. Fig. 4, A. B. C), but sometimes they remain rather after that (cf. Fig. 4, D). Thus the cystocarp is always terminal on the top of the short branch (not on the long branch). The short branch bearing cystocarp is more robust, thicker and longer than other ones. In the number of segments and pericentral cells, however, it does not differ from other ones.

This species is most closely related to *H. tenella* (C. AGARDH) NAEGELI in habit, but differs from it in the fact that the cystocarps are always terminal on the short branches and urceolate in shape. In FALKENBERG's description and figure (ENGLER. u. PRANTL's Nat. Pflanzenfam., I. Teil Abt. 2, 1897, p. 459, fig. 258, A) the cystocarps are lateral on the short branches and they are "Kugelig" or "eiförmig", while in this new species this is not the case as noted above. Comparing with *Börgesen's* plant described as *H. tenella* (Mar. Alg. of Dan. West Ind., vol. 11, 1915–1920, p. 288, fig. 288), this species can be distinguished from it by the shape of the cystocarp.

Furthermore in comparison with *Herposiphonia* spec., described by *Börgesen* (1. c. p. 474, fig. 431), this Japanese species resembles it, especially in the shape of the cystocarps. But the new species does not show such "renewed growth"

as described and figured in the above cited paper. The trichoblasts are very few in number. The branchlets are not so slender as those of foreign species. The cystocarps are always terminal as noted above.

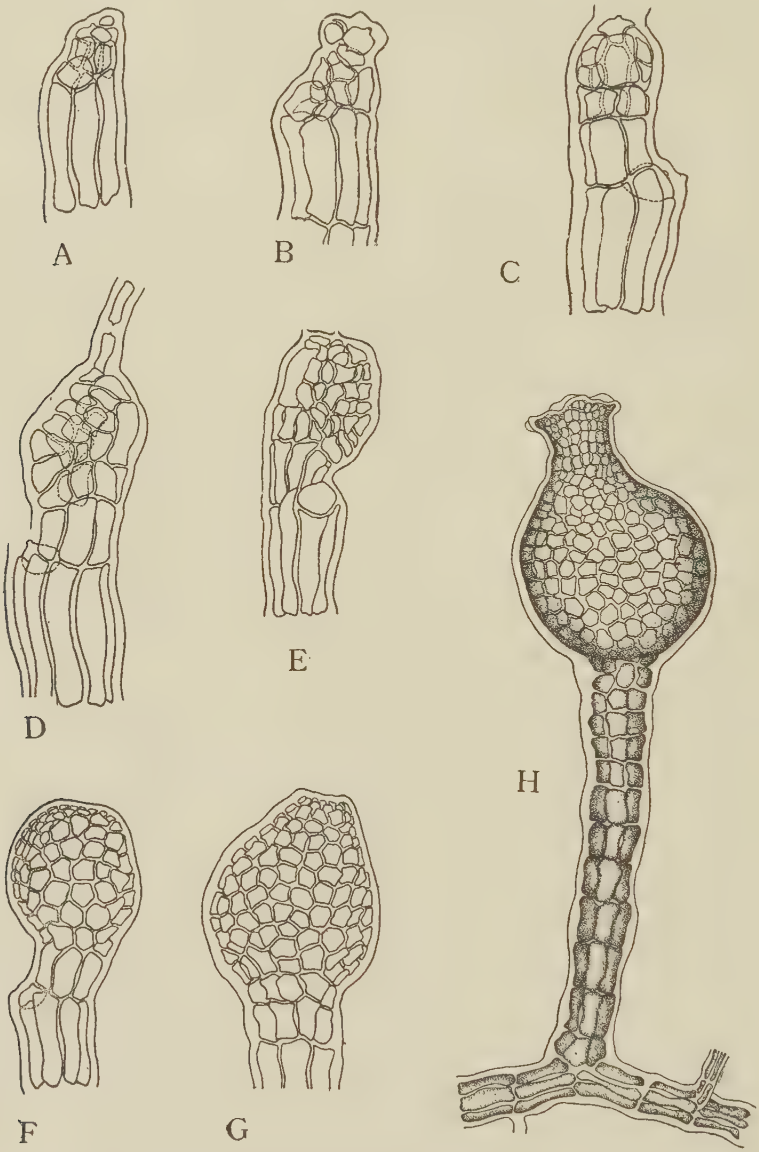


Fig. 4 *Herposiphonia terminalis* n. sp.
A-G. Development of procarps. ×150.
H. Ripe cystocarp terminated on a short branch. ×50.

In describing *H. tenella* (C. AGARDH) NAEGELI (Japanese name: *Kumonosu-himegoke*), OKAMURA could not examine any cystocarpic specimen. At Ikawatsu the writer collected quite a number of specimens of this alga including some

female ones. The examination of the habit and shape of the cystocarps reveals that they are not the same as so-called *H. tenella* (C. Agardh) Naegeli in the foreign country as noted above. Judging from the detailed description and figures of it given by Okamura (Nippon Kaisō Shi, 1936, p. 870), the writer came to the conclusion that this Ikawatsu specimen is the same as this Okamura's plant which should be identified with the writer's new species instead of Naegeli's species.

Report of Faculty of Fisheries,
Prefectural University of Mie,
Vol. 1, No. 3, July 30, 1954.

Cyclopoida Copepods of Japanese Subterranean Waters

(With 180 Text-figures and 17 Tables)

TAKASHI ITO
Faculty of Fisheries, Prefectural University of Mie

Our knowledge of the copepod fauna of Japanese subterranean waters is very meagre until noteworthy collections of subterranean-water animals were laboriously made by Mr. Y. MORIMOTO nearly all over Japan. There are only two previous works. UENO (1934a) described a new species, *Eucyclops nagasakai* from a subterranean pool, "Miwatari-ike", in a cave at Hirogawara, Taguchi-mura, Nagano Pref. IDE (1935) reported *Cyclops serrulatus* FISCHER from the same place.

Recently, Mr. YOSHINOBU MORIMOTO of Himeji Municipal High School, during his collecting travel of subterranean-water inhabiting animals in the summers of 1950, 1951 and 1952, has succeeded to obtain a considerable number of copepods from forty wells in south-western and north-eastern Japan as well as Hokkaido, and also from a limestone cave at Akiyoshi, Yamaguchi Pref. In December of 1950 and July-September of 1952, Mr. YOSHIFUMI MIURA of Tatsuno High School, Hyogo Pref., also collected seven materials of animals from a well of the Municipal Water-works of Aioi City. On the other hand, the present author obtained two materials from two wells, one at Sashiki-machi, Kumamoto Pref., Kyushu, and the other at Ishinden-machi, Mie Pref., central Japan.

Copepod materials collected by Messrs. Y. MORIMOTO and Y. MIURA from forty-seven localities all over Japan were placed at my disposal for study. Having examined these materials, I was able to recognize 16 species and 3 subspecies referable to 12 genera which belong to Cyclopoida-Copepoda, and reported them fragmentally (ITO, T., 1952, 1953a, b, and in the press). In the present paper, these results will be summarized and discussed. Before going further, I wish to express my thanks to Dr. MASUZO UÉNO for much valuable advice and correction of the original manuscript. I also express my gratitude to Messrs. Y. MORIMOTO and Y. MIURA, who kindly sent many valuable materials for the use of my study.

Localities and species found

No. 1. Well with pump; Kitami-Aioi Station, Abashiri-gun, Hokkaido; W. T. 11.8°C, pH 6.8; 9, VIII, 1952. (collected by Mr. Morimoto)
Diacyclops sp. 1♂; *Diacyclops disjunctus* (THALLWITZ) 4♀♀, 4♂♂; Copepodid (Cyclopoida) 46.

No. 2. Well with pump; Rikunbetsu-mura, Ashiyoro-gun, Hokkaido; W. T. 8.9°C, pH 6.8; 10, VIII, 1952. (Morimoto)

Diacyclops disjunctus (THALLWITZ) 2♂♂; *Diacyclops languidoides* (LILLJEBORG) 1♀, 1♂.

No. 3. Well with pump; Rikunbetsu Station, Rikunbetsu-mura, Ashiyoro-gun, Hokkaido; W. T. 9.0°C; 10, VIII, 1952. (Morimoto)
Diacyclops disjunctus (THALLWITZ) 1♂.

No. 4. Well with pump; Obihiro-city, Hokkaido; 10, VIII, 1952. (Morimoto)
Eucyclops miurai ITO 1♂; *Diacyclops disjunctus* (THALLWITZ) 1♂; Copepodid (Cyclopoida, *Diacyclops*) 3.

No. 5. Well with pump; Samani Primary School, Samani-machi, Samani-gun, Hokkaido; W. T. 12.8°C; 11, VIII, 1952. (Morimoto)
Eucyclops serrulatus (FISCHER) 2♀♀, 1♂, copepodid 9; *Speocyclops yezoensis* n. sp. 1♀; Harpacticoida 1.

No. 6. Well with pump; Samani-machi, Samani-gun, Hokkaido; W. T. 15.8°C, pH 6.2; 11, VIII, 1952. (Morimoto)
Diacyclops disjunctus (THALLWITZ) 2♂♂; *Speocyclops yezoensis* n. sp. 1♀; Copepodid (Cyclopoida) 2; Harpacticoida 1.

No. 7. Well with pump; Odate Station, Odate-city, Akita Pref. W. T. 11.1°C, pH 6.6; 6, VIII, 1952. (Morimoto)
Copepodid (Cyclopoida) 2; Harpacticoida 15.

No. 8. Well with pump; Odate-city, Akita Pref. W. T. 11.0°C; 7, VIII, 1952. (Morimoto)
Eucyclops miurai ITO 1♀; *Diacyclops disjunctus* (THALLWITZ) 2♀♀.

No. 9. Well with pump; Kamimorioka Station, Morioka-city, Iwate Pref. W. T. 12.0°C; 13, VIII, 1952. (Morimoto)
Eucyclops serrulatus (FISCHER) 4♀♀, 1♂.

No. 10. Well with pump; Moichi-mura, Shimohei-gun, Iwate Pref. W. T. 21.0°C, pH 6.4; 13, VIII, 1952. (Morimoto)
Macrocyclops fuscus (JURINE) 2♀♀; *Eucyclops serrulatus* (FISCHER) 6♀♀, 4♂♂; *Paracyclops fimbriatus* (FISCHER) 1♀; Copepodid (Cyclopoida) 6.

No. 11. Well with pump; Moichi-mura, Shimohei-gun, Iwate Pref. W. T. 11.8°C, pH 6.4; 14, VIII, 1952. (Morimoto)
Eucyclops miurai ITO 2♀♀.

No. 12. Well with pump; Moichi-mura, Shimohei-gun, Iwate Pref. 14, VIII, 1952. (Morimoto)
Eucyclops miurai ITO 2♀♀.

No. 13. Well with pump; Maiya-machi, Tome-gun, Miyagi Pref. W. T. 13.0°C, 15, VIII, 1952. (Morimoto)
Diacyclops disjunctus (THALLWITZ) 1♀ (with ovisac), 2♂♂; Copepodid (Cyclopoida, *Diacyclops*) 5.

No. 14. Well with pump; Asamizu-mura, Tome-gun, Miyagi Pref. W. T. 13.2°C; 15, VIII, 1952. (Morimoto)
Macrocyclops fuscus (JURINE) 1♀; *Eucyclops serrulatus* (FISCHER) 1♀, 3♂♂; *Eucyclops miurai* ITO 1♀; *Cyclops vicinus* ULJANIN? 1♀; *Diacyclops disjunctus* (THALLWITZ) 2♂♂.

No. 15. Artesian well; Gosen-machi, Nakakanbara-gun, Niigata Pref. W. T. 12.6°C, pH 6.8; 5, VIII, 1952. (Morimoto)
Harpacticoida 1.

No. 16. Well with pump; in which introduced the water from a spring; Gosen Station, Gosen-machi, Nakakanbara-gun, Niigata Pref.; W. T. 15.2°C; 5, VIII, 1952. (Morimoto)
Copepodid (Cyclopoida) 1; Harpacticoida 80.

No. 17. Well with pump; Ashikaga-city, Tochigi Pref. W. T. 15.0°C, pH 6.0; 2, VIII, 1951. (Morimoto)

Tropocyclops prasinus (FISCHER) 1♀; Copepodid (Cyclopoida) 1.

No. 18. Well with pump; Hachioji-city, Tokyo; W. T. 16.0°C, pH 6.2; 29, VII, 1951. (Morimoto)
Megacyclops viridis (JURINE) 1♂; *Diacyclops languidoides* (LILLJEBORG) 1♀.

No. 19. Well with pump; Hachioji-city, Tokyo; W. T. 16.0°C, pH 5.8; 29, VII, 1951. (Morimoto)
Diacyclops languidoides japonicus ITO 1♀; Copepodid (Cyclopoida) 1.

No. 20. Well with pump; Hanno-machi, Iruma-gun, Saitama Pref. 29, VII, 1951. (Morimoto)
Eucyclops miurai ITO 1♀.

No. 21. Well with pump; Nerima, Tokyo; W. T. 15.5°C; 29, VII, 1951. (Morimoto)
Eucyclops miurai ITO 2♀♀, 2♂♂; Copepodid (Cyclopoida) 5.

No. 22. Well with pump; Shimotakaido, Suginami, Tokyo; W. T. 16.0°C, pH 6.0; 2, VIII, 1951. (Morimoto)
Copepodid (Cyclopoida) 1.

No. 23. Well with pump; Enzan-machi, Higashiyamanashi-gun, Yamanashi Pref. W. T. 15.5°C, pH 6.1; 27, VII, 1951. (Morimoto)
Diacyclops languidoides (LILLJEBORG) 6♀♀, 5♂♂.

No. 24. Well with pump, in which introduced the water from a spring; Shinanoaoyagi Station, Kanazawa-mura, Nagano Pref. W. T. 17.0°C; 26, VII, 1951. (Morimoto)
Eucyclops serrulatus (FISCHER) 2♀♀, 1♂; *Tropocyclops prasinus* (FISCHER) 1♀; *Microcyclops (Microcyclops) varicans* (SARS) 1♀; Copepodid (Cyclopoida) 3.

No. 25. Well with pump; Kanazaw-mura, Suwa-gun, Nagano Pref. W. T. 16.3°C, pH 6.0; 26, VII, 1951. (Morimoto)
Diacyclops languidoides (LILLJEBORG) 17♀♀, 4♂♂; Copepedid (Cyclopoida) 1.

No. 26. Well with pump; Fukushima-machi, Nishichikuma-gun, Nagano Pref. W. T. 15.0°C; 26, VII, 1951. (Morimoto)
Diacyclops languidoides (LILLJEBORG) 3♀♀, 2♂♂.

No. 27. Well with pump; Furukawa-machi, Yoshiki-gun, Gifu Pref. W. T. 12.0°C, pH 6.2; 24, VII, 1951. (Morimoto)
Diacyclops languidoides (LILLJEBORG) 10♀♀, 2♂♂.

No. 28. Well with pump; Furukawa-machi, Yoshiki-gun, Gifu Pref. W. T. 12.0°C, pH 6.2; 24, VII, 1951. (Morimoto)
Diacyclops languidoides (LILLJEBORG) 4♀♀.

No. 29. Well with pump; Nada-machi, Takayama-city, Gifu Pref. W. T. 14.5°C, pH 6.8; 25, VII, 1951. (Morimoto)
Copepodid (Cyclopoida) 2.

No. 30. Well with pump; Hachiken-machi, Takayama-city, Gifu Pref. W. T. 13.0°C, pH 5.8; 25, VII, 1951. (Morimoto)
Copepodid (Cyclopoida) 1.

No. 31. Well with pump; Ota-machi, Kamo-gun, Gifu Pref. W. T. 18.0°C; 25, VII, 1951. (Morimoto)
Diacyclops disjunctus (THALLWITZ)? 1♂.

No. 32. Well with pump; Takebu-city, Fukui Pref. W. T. 14.0°C, pH 6.2; 23, VII, 1951. (Morimoto)
Eucyclops miurai ITO 1♀; *Diacyclops disjunctus* (THALLWITZ) 2♀♀, 2♂♂.

No. 33. Well with pump; Takebu-city, Fukui Pref. W. T. 13.8°C, pH 7.0; 4, VIII, 1952. (Morimoto)
Eucyclyps miurai ITO 5♀♀, 1♂; *Megacyclops viridis takebuensis* n. subsp. 2♀♀; *Diacyclops disjunctus* (THALLWITZ) 4♀♀, 3♂♂; *Diacyclops languidoides* (LILLJEBORG) 13♀♀, 3♂♂; Copepodid (Cyclopoida) 2; Harpacticoida 4.

No. 34. Well with pump; Ishinden-machi, Kawage-gun, Mie Pref. 26, XI, 1952. (collected by the author)
Diacyclops disjunctus (THALLWITZ) 25♀♀, copepodid 2.

No. 35.* Wells used as the source of water, in the gathering-ground of the water-works, Himeji-city, Hyogo Pref. (Morimoto)
Eucyclops miurai ITO; *Acanthocyclops morimotoi* ITO; *Diacyclops disjunctus* (THALLWITZ); *Diacyclops languidoides japonicus* ITO; *Canthocamptus staphylinus* JURINE ?.

No. 36.* Wells used as the source of water, in the gathering-ground of the water-works, Aioi-city, Hyogo Pref. (collected by Mr. Miura)
Eucyclops serrulatus (FISCHER); *Eucyclops miurai* ITO; *Paracyclops fimbriatus* (FISCHER); *Acanthocyclops morimotoi* ITO; *Diacyclops disjunctus* (THALLWITZ); *Diacyclops languidoides japonicus* ITO; *Atthyella* sp.

No. 37. ———; 10, VII, 1952. (Miura)
Eucyclops murai ITO 1♀.

No. 38. ———; 17, VII, 1952. (Miura)
Eucyclops serrulatus (FISCHER) 4♀♀, 1♂; *Eucyclops miurai* ITO 22♀♀, 23♂♂; *Paracyclops fimbriatus* (FISCHER) 1♂; *Diacyclops disjunctus* (THALLWITZ) 2♀♀, 2♂♂, copepodid 11; *Diacyclops languidoides japonicus* ITO 11♀♀, 8♂♂; Copepodid (Cyclopoida) 9; Harpacticoida 8.

No. 39. ———; 18, VII, 1952. (Miura)
Eucyclops serrulatus (FISCHER) ♀♀, ♂♂; *Eucyclops miurai* ITO ♀♀, ♂♂; *Megacyclops viridis* (JURINE) 1♀; *Diacyclops disjunctus* (THALLWITZ) ♀♀, ♂♂; *Diacyclops languidoides japonicus* ITO ♀♀, ♂♂; Harpacticoida abundant.

No. 40. ———; 4, IX, 1952. (Miura)
Megacyclops viridis (JURINE) copepodid (♀) 1.

No. 41. ———; 19, IX, 1952. (Miura)
Eucyclops serrulatus (FISCHER) 1♀, 1♂; *Eucyclops miurai* ITO ♀♀, ♂♂; *Paracyclops fimbriatus* (FISCHER) 1♀; *Diacyclops disjunctus* (THALLWITZ) ♀♀, ♂♂; *Diacyclops languidoides japonicus* ITO ♀♀, ♂♂; Harpacticoida abundant.

No. 42. Well with pump; Taishi-machi, Ibo-gun, Hyogo Pref. VII-X, 1952. (Morimoto)
Eucyclops miurai ITO 58♀♀, 9♂♂; *Megacyclops viridis* (JURINE) 1♀, copepodid v 2; *Diacyclops languidoides japonicus* ITO 13♀♀, 11♂♂; Copepodid (Cyclopoida) 39.

No. 43. Well with pump; Katsumada-machi, Katsuda-gun, Okayama Pref. W. T. 17.3°C; pH 6.2; 28, VIII, 1951. (Morimoto)
Diacyclops disjunctus (THALLWITZ) 2♀♀; Copepodid (Cyclopoida) 2.

No. 44. Well with pump; Niimi-machi, Atetsu-gun, Okayama Pref. W. T. 18.8°C, pH 6.2; 28, VIII, 1951. (Morimoto)
Nothing.

No. 45. Well with pump; Masuda-city, Shimane Pref. W. T. 17.5°C, pH 6.2; 27, VIII, 1951. (Morimoto)
Eucyclops serrulatus (FISCHER) 4♀♀, 2♂♂; *Mesocyclops leuckarti* (CLAUS) 2♀♀.

No. 46. Well with pump; Tonda-machi, Tsuno-gun, Yamaguchi Pref. W. T. 17.0°C, pH 6.2; 26, VIII, 1951. (Morimoto)
Megacyclops viridis (JURINE) copepodid V 1; *Diacyclops languidoides suoensis* n. subsp. 2♀♀, copepodid V 1.

No. 47. Well with pump; Tokuyama-city, Yamaguchi Pref. W. T. 18.0°C, pH 6.2; 26, VIII, 1951. (Morimoto)
Eucyclops serrulatus (FISCHER) 2♀♀, 1♂.

No. 48. Running waters in the limestone cave, Shuhodo, Akiyoshi, Yamaguchi Pref.

W. T. 15.8°C, pH 7.8; 26, VIII, 1951. (Morimoto)
Mesocyclops leuckarti (CLAUS) ♀ and copepodid abundant.

No. 49.* Well with pump; Sashiki-machi, Ashikita-gun, Kumamoto Pref. (the author)
Macrocyclops albidus (JURINE); *Eucyclops serrulatus* (FISCHER); *Thermocyclops uénoi* ITO.

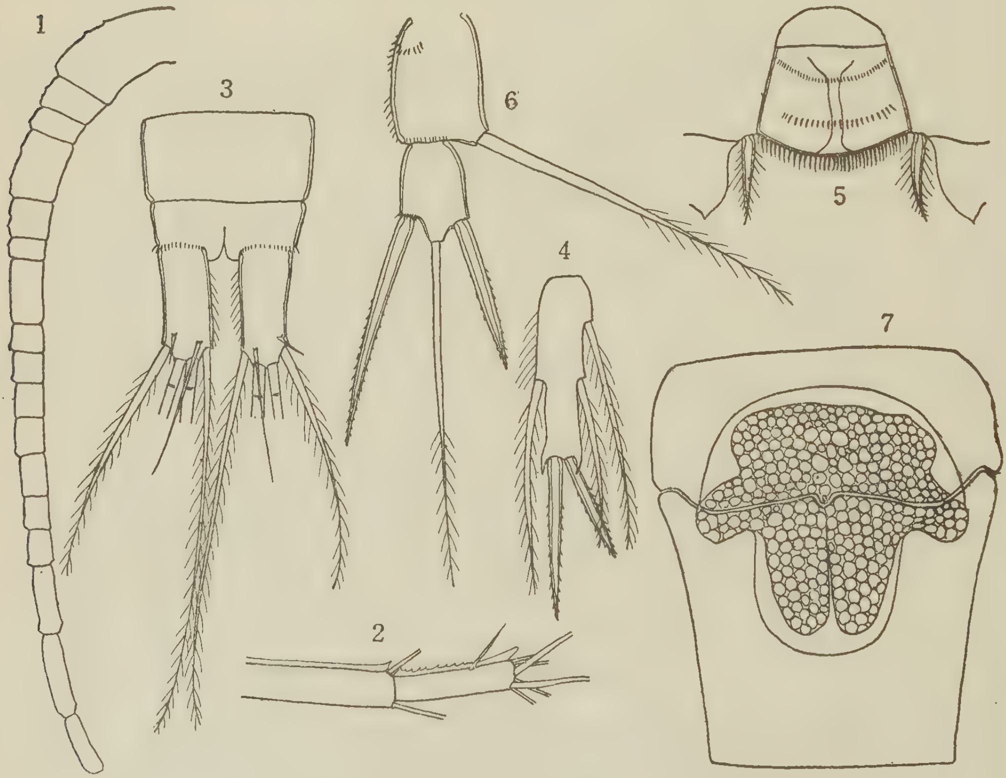
N.B. The species marked with an asterisk, see ITO (1952).

Descriptions

1) *Macrocyclops fuscus* (JURINE)
(Figs. 1–7; Table 1)

Female.—Length 1.76–1.89 mm. Body white, nauplius eye entirely absent.

Furcal rami short and stout, 2.4–2.5 times as long as wide; inner margin hairy; lateral seta very small and located near end; furcal setae well-developed, their length from inner to outer and dorsal as follows:



Figs. 1–7. *Macrocyclops fuscus* (JURINE), Female, Moichi (Iwate)
1. First antenna;
2. First antenna, distal segments;
3. Furcal rami (ventral view);
4. Leg 4, endopodite 3;
5. Connecting plate of leg 4;
6. Leg 5;
7. Receptaculum seminis.

	I (in.)	II	III	IV (ou.)	V (dor.)
Moichi (Iwate)	421.2	959.4	631.8	257.4	175.5 (μ)
〃 (〃)	397.8	924.3	585.0	245.7	163.8 (μ)
Asamizu (Miyagi)	444.6	842.4	608.4	280.8	152.1 (μ)

Inner furcal seta longer than the outer (1.6:1), and about 3 times as long as furcal rami; dorsal seta very small and short, about 1/3 as long as the inner seta.

First antenna of 17 segments, extending back to end of cephalothorax; segs. 15–17 with broad hyaline membrane; in seg. 17 this membrane projecting beyond end of the segment, and is deeply serrated in its proximal half.

Leg 1—leg 4; formula 3,3/3,3/3,3/3,3; spine-formula 3,4,4,3; seta-formula 5,5,5,5. Leg 4, endopodite 3 long and slender, about 3 times as long as wide (2.9–3.1:1); inner terminal spine shorter than the outer (0.6–0.7:1), and outer spine 87–109% of length of endopodite 3; distal inner seta of endopodite 3 well developed.

Connecting plate of leg 4 with convex margin, armed with a fringe of strong spines; posterior surface with 2 transverse rows of spinules. Leg 5, seg 1 much longer than seg. 2, hairy on inner side; seg. 2 bearing a long median terminal seta and on outer and inner spine, the latter much longer.

Receptaculum seminis large, posterior part cleft into two apposed sacs.

Male.—Not found.

Locality.—No. 10 (2♀♀); No. 14 (1♀).

2) *Macrocyclops albidus* (Jurine)

(Figs. 8–12)

Female.—Length 1.4–1.8 mm. Body dark brown, with a distinct red nauplius eye.

Furcal rami nearly 3 times as long as wide; inner margin with hairs; lateral seta inserted very near apex. Inner furcal seta about 2 times as long as the outer.

First antenna of 17 segments, extending beyond cephalothorax; segs. 15–17 with broad hyaline membrane; these membranes apparently smooth.

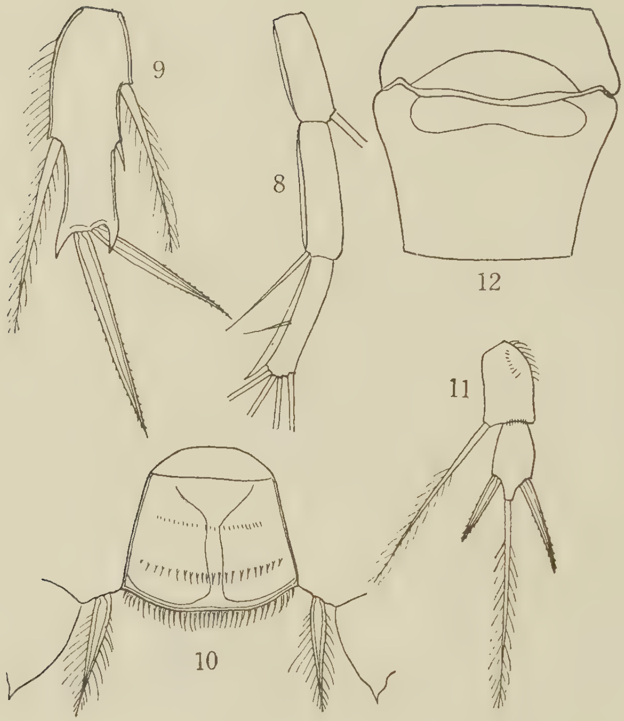
Leg 1—leg 4; formula 3,3/3,3/3,3/3,3; spine-formula 3,4,4,3; seta-formula 5,5,5,5. Leg 4, endopodite 3 less than 3 times as long as wide (about 2.5:1); distal inner seta greatly reduced, not plumose; outer terminal spine very little longer than the inner (1.14–1.17:1).

Connecting plate of leg 4 resembles that of *M. fuscus*. (Fig. 5)

Receptaculum seminis with posterior part not produced backwards, concave behind.

Male.—Not found.

Locality.—No. 49 (5♀♀).



Figs. 8–12. *Macrocyclops albidus* (Jurine), Female, Sashiki (Kumamoto)
8. First antenna, distal parts; 9. Leg 4, endopodite 3;
10. Connecting plate of leg 4; 11. Leg 5;
12. Receptaculum seminis.

3) *Eucyclops serrulatus* (Fischer)
(Figs. 13–16, Table 2)

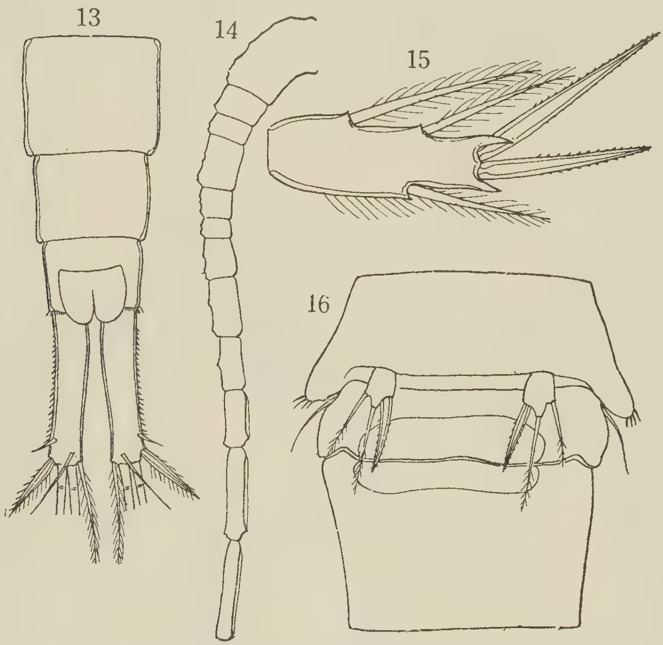
Female.—Length 0.81–1.21 mm. Body brownish yellow and with a distinct red nauplius eye (Kanazawa, Sashiki), or body white and nauplius eye entirely absent (Samani, Morioka, Moichi, Asamizu, Aioi, Masuda, Tokuyama).

Furcal rami very variable in length, 3.8–5.9 times as long as wide, divergent, and slightly curved outwards; outer margin with distinct longitudinal row of small spines; lateral seta located very near end, at distal 1/5, four terminal and a dorsal furcal setae well-developed, their lengths from inner to outer and dorsal as follows:

		I (in.)	II	III	IV (ou.)	V (dor.)
Kanazawa	(Nagano)	88	440	286	57.2	45 (μ)
Aioi	(Hyogo)	75	450.8	303.6	52.5	45 (μ)
〃	(〃)	75	441.6	303.6	52.5	42.5 (μ)

Inner furcal seta less than twice as long as the outer (1.1–1.5:1), and much shorter than the ramus; outer seta stout and spine-like, with long hairs on inner side, and small denticles on outer margin; dorsal seta shorter than the outer.

First antenna of 12 segments, rather long and slender, reaching beyond cephalothorax; last 3 segments very long and slender, with a broad hyaline membrane; edge of this membrane apparently smooth.



Figs. 13–16. *Eucyclops serrulatus* (FISCHER), Aioi (Hyogo)
13. Furcal rami (dorsal view); 14. First antenna;
15. Leg 4, endopodite 3; 16. Leg 5 and Receptaculum seminis.

Leg 1—leg 4; formula 3,3/3,3/3,3/3,3; spine-formula 3,4,4,3; seta-formula 5,5,5,5. Leg 4, endopodite 3 long and slender, variable in length, 1.6–2.8 times as long as wide; inner terminal spine longer than the outer (1.2–1.5:1). 3 setae not reaching nearly to ends of terminal spines. Leg 5 a simple plate bearing stout inner spine and 2 slender setae.

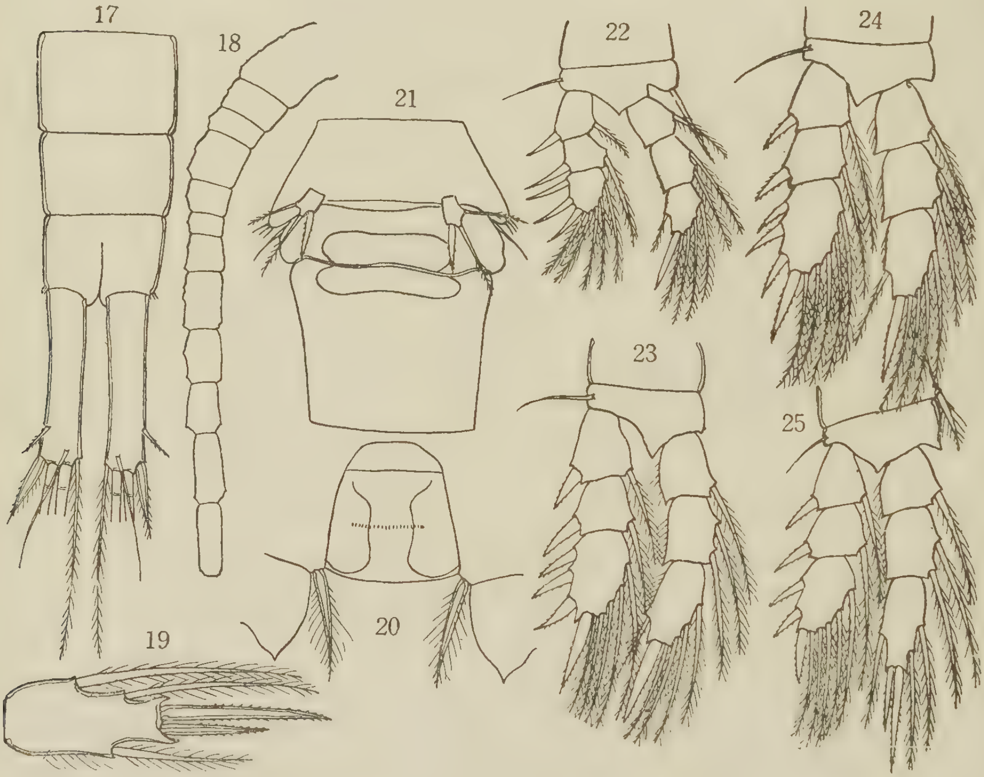
Receptaculum seminis with anterior part larger than posterior part, and with a deep median concavity.

Male.—Length 0.68–1.00 mm. More slender than female; body white, nauplius eye entirely absent as in female, but specimens collected from Kanazawa (Nagano Pref.) and Sashiki (Kumamoto Pref., Kyushu) with a distinct red nauplius eye. Furcal rami without lateral denticles, shorter than in female, 3.1–4.0 times as long as wide; inner furcal seta longer than in female, 1.5–2.1 times as long

as the outer, and as long as the ramus.

Locality.—No. 5 (2♀♀, 1♂); No. 9 (4♀♀, 1♂); No. 10 (6♀♀, 4♂♂); No. 14 (1♀, 3♂♂); No. 24 (2♀♀, 1♂); No. 36 (4♀♀, 2♂♂); No. 47 (2♀♀, 1♂); No. 49 (13♀♀, 3♂♂).

To the author's mind, *Eucyclops nagasakai*[1] recorded by Dr. Uéno (1934 a, b) from a subterranean pool in a cave at Hirogawara in Nagano Pref., and also from a well at the town of Pi-tzu-wo in Kwantung Prov., southern Manchuria seems to be identical with *Eucyclops serrulatus* (Fischer), as pointed out by Kiefer (1938 a).



Figs. 17–25. *Eucyclops miurai* Ito, Female, Himeji (Hyogo)
17. Furcal rami (ventral view); 18. First antenna;
19. Leg 4, endopodite 3; 20. Connecting plate of leg 4;
21. Leg 5 and Receptaculum seminis; 22. Leg 1;
23. Leg 2; 24. Leg 3;
25. Leg 4.

1) *Eucyclops nagasaki* in the original description by Uéno who dedicated this specific trivial name to Mr. R. Nagasaka. The trivial name, *nagasaki* is obviously typographic misprint.

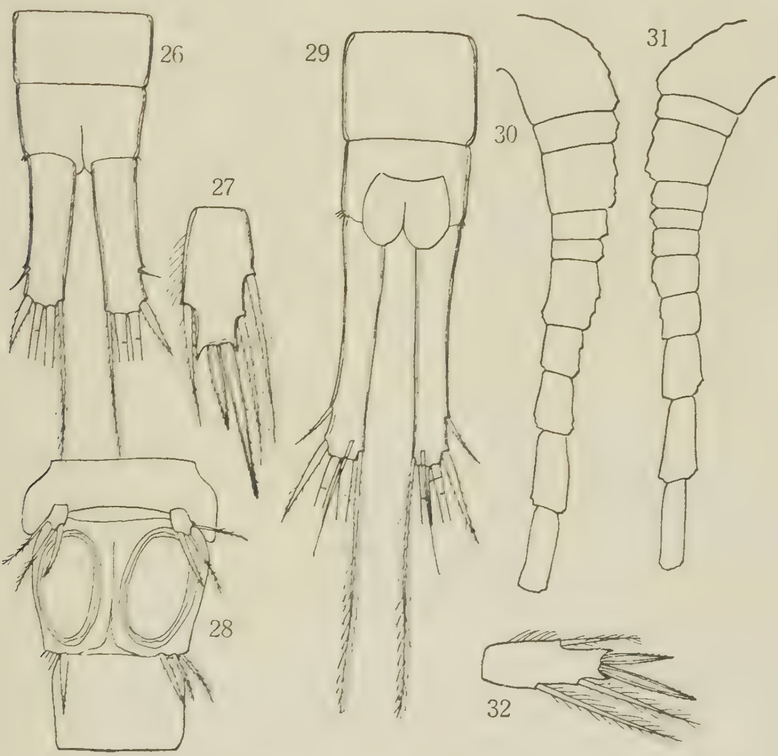
4) *Eucyclops miurai* Ito

(Figs. 17–25, Figs. 26–32, Figs. 33–41 ; Table 3)

1952. Ito, T., Report of Faculty of Fisheries, Prefectural University of Mie. Vol. 1, No. 2, p. 116, Figs. 1–7.

Female.—Length 0.62–0.98 mm., shorter than *Eucyclops serrulatus*. Body white, nauplius eye entirely absent.

Furcal rami nearly parallel, very variable in length, 3.1–6.8 times as long as wide ; outer margin without longitudinal row of small spines as in *Eucyclops serrulatus ;* lateral seta inserted near end, at distal 1/5 ; four terminal and a dorsal furcal setae well-developed, their lengths are from inner to outer and dorsal as follows :



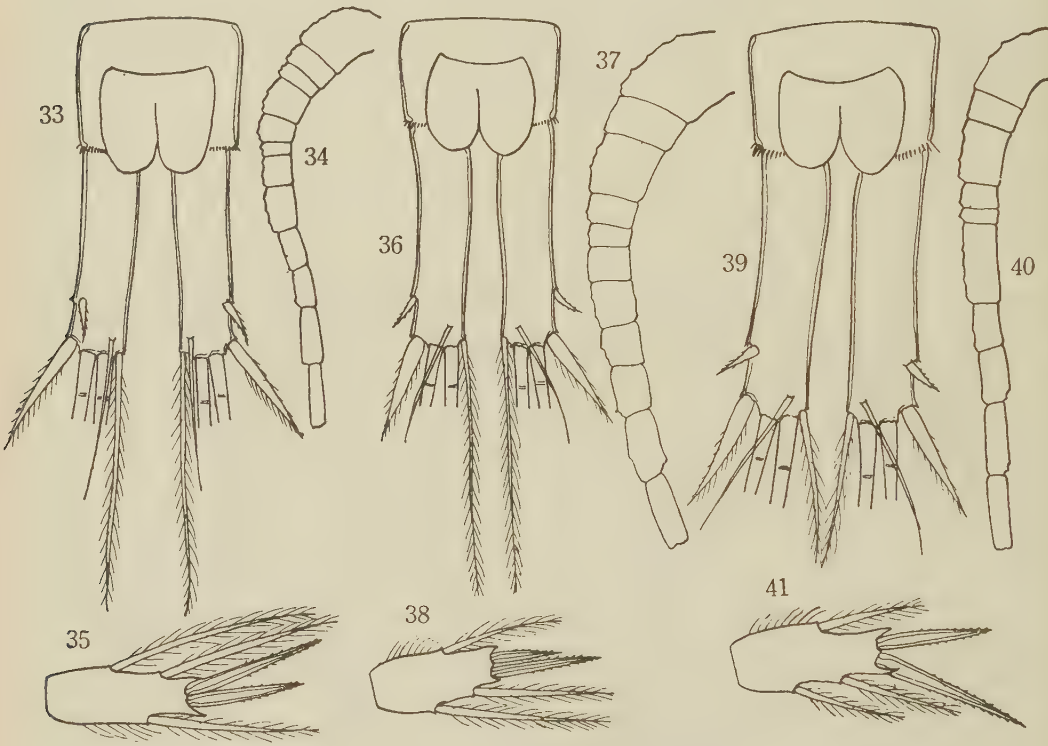
Figs. 26–32. *Eucyclops miurai* Ito

26–28. Male ;
26. 29. Furcal rami ;
28. Leg 5 and leg 6 ;
31. First antenna (11-segmented).
29–32. Female, Aioi (Hyogo).
27. 32. Leg 4, endopodite 3 ;
30. First antenna (10-segmented) ;

	I (in.)	II	III	IV (ou.)	V (dor.)
Hanno (Saitama)	105	360.8	233.2	45	48 (μ)
Takebu (Fukui)	99	396	242	45	51 (μ)

Himeji (Hyogo)	100	322	220.8	36.8	45 (μ)
〃 (〃)	77.5	331.2	211.6	32.5	50 (μ)
Aioi (〃)	100	303	202.4	37.5	55 (μ)
〃 (〃)	99	269.1	198.9	36	48 (μ)
〃 (〃)	93	304.2	198.9	30	48 (μ)

Inner furcal seta much longer than the outer (1.3–3.1:1), and generally longer or rarely shorter than the ramus; outer seta slightly spine-like and shorter than dorsal seta.



Figs. 33–41. *Eucyclops miurai* Ito, Female.
33–35. Takebu (Fukui); 36–38. Hanno (Saitama);
39–41. Moichi (Iwate);
33. 36. 39. Furcal rami; 34. First antenna (of 12 segments);
37. First antenna (of 11 segments); 40. First antenna (of 10 segments);
35. 38. 41. Leg 4, endopodite 3.

First antenna of usually 12 segments, rarely of 11 or 10 segments; variable not only according to locality; e.g. of 12 segments.—[Moichi (No. 11), Nerima (No. 21), Takebu (No. 32, No. 33), Himeji (No. 35), Aioi (No. 36, No. 38, No. 39, No. 41), Taishi (No. 42)]. of 11 segments.—[Hanno (No. 20), Aioi (No. 37, No. 38, No. 39, No. 41), Taishi (No. 42)]. of 10 segments.—[Odate (No. 8), Moichi (No. 12), Asamizu (No. 14), Aioi (No. 38, No. 39, No. 41), Taishi (No. 42)], but also to individuals within a same locality, (e.g. in Aioi and Taishi). First antenna

also relatively short, reaching to the posterior end of cephalothorax, without hyaline membrane on distal segments.

Leg 1—leg 4; formula 3,3/3,3/3,3/3,3; spine-formula 3,4,4,3; seta-formula 5,5,5,5. Leg 4, endopodite 3 relatively long and slender, 1.8–2.8 times as long as wide, and resembling that of *Eucyclops serrulatus;* terminal spines unequal, inner spine longer than the outer (1.2–2.0:1) and usually as long as endopodite 3 (80–125%); 3 setae variable in length, not reaching to ends of terminal spines, or rarely extending beyond ends of these spines.

Connecting plate of leg 4 and leg 5, as shown in Figs. 20 and 21, respectively, resembles those of *Eucyclops serrulatus* (FISCHER).

Receptaculum seminis with anterior part larger than posterior part, and with a deep median concavity, resembling that of *E. serrulatus.*

Male.—Length 0.53–0.94 mm. Body white, without nauplius eye as in the female, varable in length, more slender the female; furcal rami shorter than in in female, 3.0–5.0 times as long as wide, without lateral denticles; inner furcal seta much longer than the outer (2.1–3.1:1), and a little longer than furcal rami. Leg 6, inner spine not reaching to posterior end of abdominal segment 2, and shorter than two outer setae.

Locality.—No. 4 (1♂); No. 8 (1♀); No. 11 (2♀♀); No. 12 (2♀♀); No. 14 (1♀); No. 20 (1♀); No. 21 (2♀♀, 2♂♂); No. 32 (1♀); No. 33 (5♀♀, 1♂); No. 35 (6♀♀, 4♂♂); No. 36 (1♀, 6♂♂); No. 37 (1♀); No. 38 (22♀♀, 23♂♂); No. 39 (♀♀, ♂♂); No. 41 (♀♀, ♂♂); No. 42 (58♀♀, 9♂♂).

5) *Tropocyclops prasinus* (FISCHER)

(Figs. 42–47, Table 4)

Female.—Length 0.74 mm. Body white, without nauplius eye.

Furcal rami very short, 2.2 times as long as wide; without lateral spinules; lateral seta at or slightly beyond middle; lengths of four terminal and dorsal furcal setae are from inner to outer and dorsal as follows:

	I (in.)	II	III	IV (ou.)	V (dor.)
Kanazawa (Nagano)	57	228.8	198.0	36	54 (μ)

Inner furcal seta much longer than the outer (1.6:1) and also longer than the ramus (1.5:1); outer seta shorter than the dorsal seta; the longest furcal seta 5.0 times as long as furcal rami.

First antenna of 12 segments, very long and slender, extending backwards beyond anterior division, without hyaline membrane on distal segments.

Leg 1—leg 4; formula 3,3/3,3/3,3/3,3; spine-formula 3,4,4,3; seta-formula 5,5,5,5. Leg 4, endopodite 3 about 3 times as long as wide (2.6:1); inner terminal spine much longer than the outer, nearly twice as long as the outer spine, and

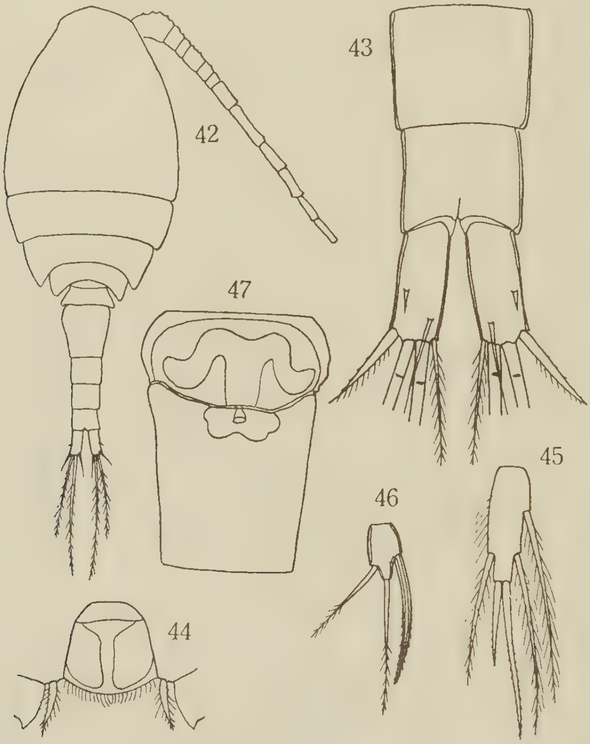
also much longer than endopodite 3 (1.6:1). Connecting plate of leg 4 with convex margin, and transverse rows of spinules present on surface.

Leg 5 a small plate, bearing 2 setae and a long slender inner spine.

Receptaculum seminis of peculiar form as shown in Fig. 47.

Male.—Unknown.

Locality.—No. 17 (1♀); No. 24 (1♀).



Figs. 42–47. *Tropocyclops prasinus* (Fischer), Female
Kanazawa (Nagano)

42. Body (dorsal); 43. Furcal rami (ventral);
44. Connecting plate of leg 4; 45. Leg 4, endopodite 3;
46. Leg 5; 47. Receptaculum seminis.

6) *Paracyclops fimbratus* (Fischer)

(Figs. 48–52, Figs. 53–56; Table 5)

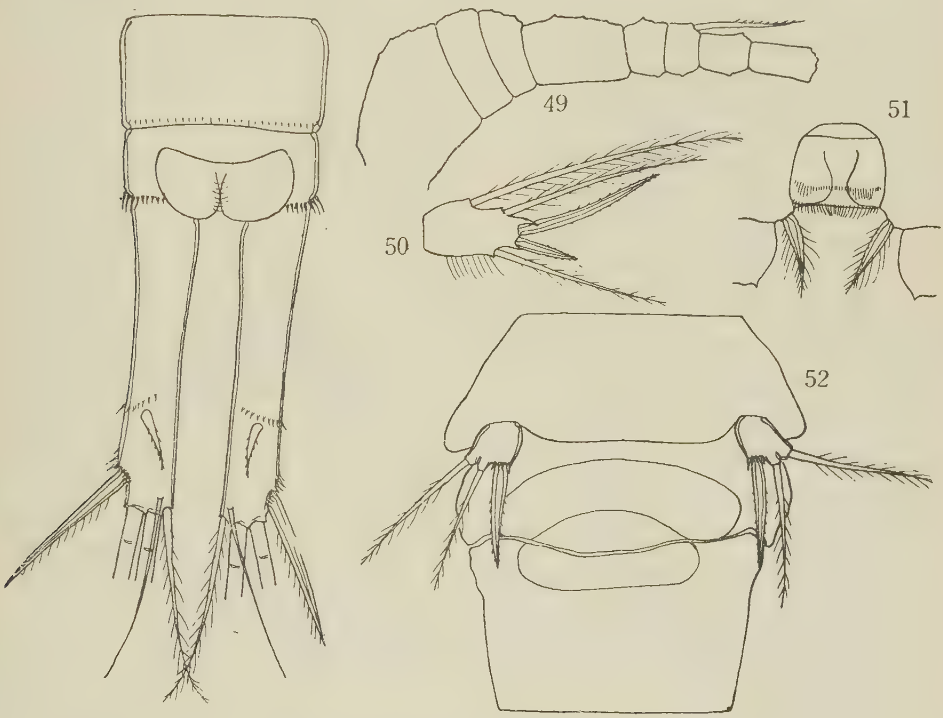
Female.—Length 0.82–0.87 mm. Body white, without nauplius eye.

Furcal rami placed relatively wide apart, slightly divergent, and much slender, 6.3–6.7 times as long as wide; lateral seta inserted near end, at about 1/4, with a few transversely arranged denticules in front of the lateral seta; furcal setae, four terminal and a dorsal well-developed, their lengths are from inner to outer and dorsal as follows:

		I (in.)	II	III	IV (ou.)	V (dor.)
Moichi (Iwate)	(♀)	72	374.4	222.3	60	72 (μ)
Aioi (Hyogo)	(♀)	57	374.4	210.6	54	69 (μ)
〃 (〃)	(♂)	55	368	202.4	52.5	45 (μ)
〃 (〃)	(♂)	54	386.1	222.3	51	63 (μ)

Inner furcal seta a little longer than the outer (1.1–1.2:1), and a little longer than half of furcal rami; outer seta spine-like, slightly shorter than the dorsal seta.

First antenna very short, consisting of 8 segments, of which the 4th is relatively long.



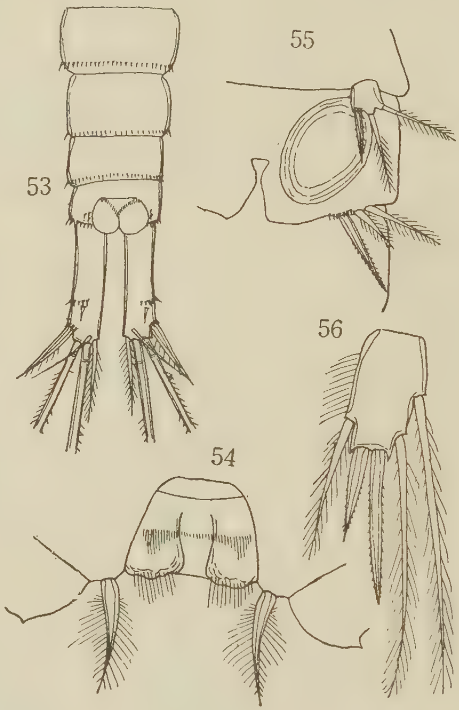
Figs. 48–52. *Paracyclops fimbriatus* (Fischer), Female, Moichi (Iwate)
48. Furcal rami (dorsal); 49. First antenna;
50. Leg 4, endopodite 3; 51. Connecting plate of leg 4;
52. Leg 5 and Receptaculum seminis.

Leg 1—leg 4; formula 3,3/3,3/3,3/3,3; spine-formula 3,4,4,3; seta-formula 5,5,5,5. Leg 4, endopodite 3 less than 2 times as long as wide (1.7–1.8:1); terminal spines very unequal, the inner spine about 2 times as long as the outer spine (1.8–2.3:1) and much longer than endopodite 3 (145–150%). Leg 5 unsegmented, with 2 outer setae and a stout inner spine; the setae usually equal in length, or the outer seta a little longer than the inner.

Connecting plate of leg 4 as shown in Fig. 51. Receptaculum seminis as shown in Fig. 52.

Male.—Length 0.67–0.69 mm. Body white, nauplius eye entirely absent as in the female. Furcal rami not so long and slender as in the female, about 4 times as long as wide (4.0–4.1:1), and with distal transverse row of denticles more marked. Leg 1—leg 4, formulae as in the female; leg 4, endopodite 3 less than 2 times as long as wide (1.7–1.8:1) as in female, inner terminal spine which is longer than the outer (1.6–1.8:1) and also the segment (133–136%). Connecting plate of leg 4 and of leg 5 as in female (Fig. 54 and Fig. 55).

Locality.—No. 10 (1♀); No. 36 (1♂); No. 38 (1♂); No. 41 (1♀).



Figs. 53–56. *Paracyclops fimbriatus* (FISCHER), Male, Aioi (Hyogo)
53. Furcal rami (dorsal);
54. Connecting plate of leg 4;
55. Leg 5 and leg 6;
56. Leg 4, endopodite 3.

7) *Cyclops vicinus* ULJANIN? (Figs. 57–60, Table 6)

Female.—Length 1.35 mm. Body white, without nauplius eye, thoracic somite 4 with angles not produced into long pointed wings.

Furcal rami long and slender, 4.1 times as long as wide; inner margin very hairy; lateral seta situated at distal 1/4; lengths of setae, four terminal and a single dorsal furcal, are from the inner to the outer and the dorsal as follows:

	I (in.)	II	III	IV (ou.)	V (dor.)
Asamizu (Miyagi)	128	376	280	76	76 (μ)

Inner furcal seta much longer than the outer (1.6:1), slightly shorter than furcal rami; outer seta as long as the dorsal seta (1.0:1).

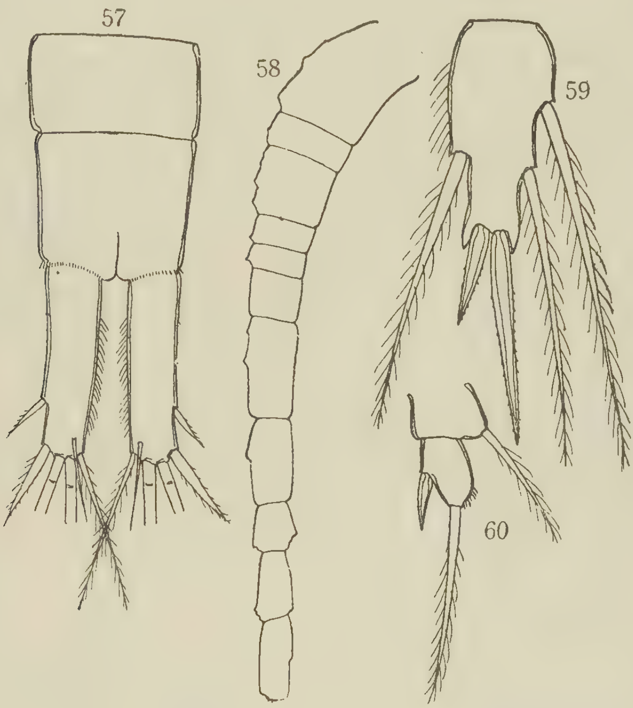
First antenna of 11 segments, reaching to porterior end of cephalothorax.

Legs 1–4; formula 3,3/3,3/3,3/3,3; spine-formula 2,3,3,3; seta-formula 5,5,5,5. Leg 4, endopodite 3 long and slender, about twice as long as wide (1.9:1), inner terminal spine twice as long as the outer, but slightly longer than segment (104%). Leg 5 as shown in Fig. 60. Receptaculum seminis not distinct.

Male.—Not found.

Locality.—No. 14 (1♀)

This animal found in Asamizu (Miyagi Pref.) accords with the description of *Cyclops vicinus* in the structures of leg 5, leg formulae, and endopodite 3 of leg 4, but differs from that in regard to the first antenna and the form of the last segment of anterior division. The animal under consideration probably belongs to the copepodid V of *Cyclops vicinus*.



Figs. 57–60. *Cyclops vicinus* ULJANIN ?, Asamizu (Miyagi)
57. Furcal rami (ventral); 58. First antenna (11 segmented); 59. Leg 4, endopodite 3; 60. Leg 5.

8) *Megacyclops viridis* (JURINE)
(Figs. 61–67, Figs. 68–74; Table 7)

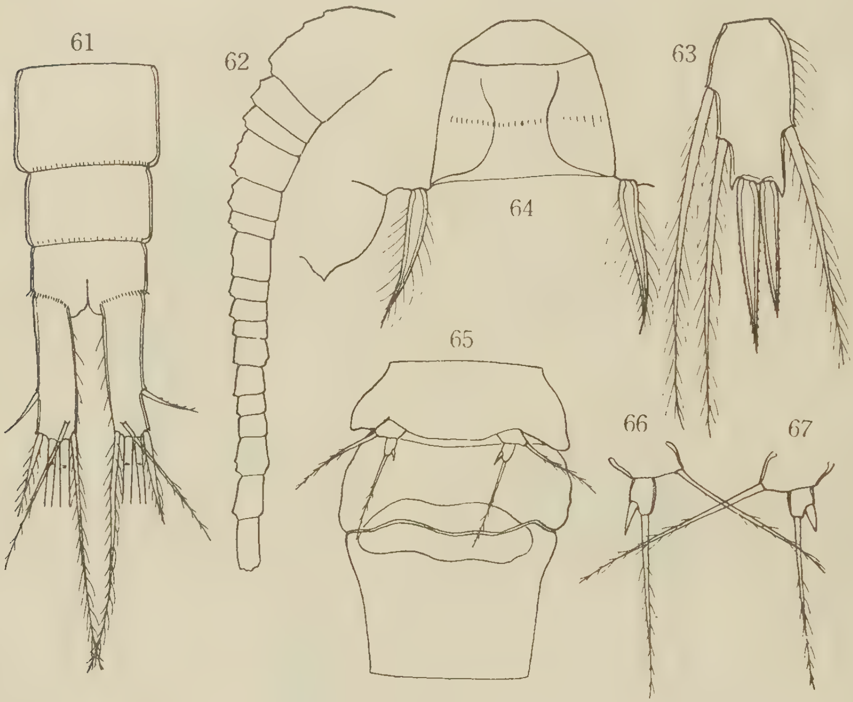
Female.—Length 1.10–1.28 mm. Body white, without nauplius eye.

Furcal rami relatively short, 3.3–3.9 times as long as wide; inner margin profusely hairy; lateral seta inserted at about distal 1/3; furcal setae, four terminal and a single dorsal, well developed, their length are from the inner to the outer and the dorsal as follows:

		I (in.)	II	III	IV (ou.)	V (dor.)
Hachioji (Tokyo)	(♂)	232	422.4	295.6	88	120 (μ)
Aioi (Hyogo)	(♀)	192	702	397.8	75	117 (μ)
Taishi (Hyogo)	(♀)	210	655.2	397.8	75	105 (μ)

Inner furcal seta remarkably longer than the outer (2.6–2.8:1), and also much longer than furcal rami (about 2:1); dorsal seta longer than the outer.

First antenna of 17 segments, reaching nearly end of thoracic somite 1; without hyaline membrane on distal segments.



Figs. 61–67. *Megacyclops viridis* (JURINE), Female, Aioi (Hyogo).
61. Furcal rami (ventral); 62. First antenna; 63. Endopodite 3 of leg 4; 64. Connecting plate of leg 4; 65. Leg 5 and Receptaculum seminis; 66. 67. Leg 5.

Legs 1–4; formula 3,3/3,3/3,3/3,3; spine-formula 2,3,3,3; seta-formula 4,4,4,4. Leg 4, endopodite 3 about 2 times as long as wide (1.9:1); terminal spines unequal, inner one longer than the outer, (1.2–1.4:1), and also longer than the segment (111–124%); setae extending beyond ends of terminal spines. Connecting plate of leg 4 as shown in Fig. 64.

Leg 5 with basal segment very broad; segment 2 small and slender; inner spine very small, inserted beyond middle.

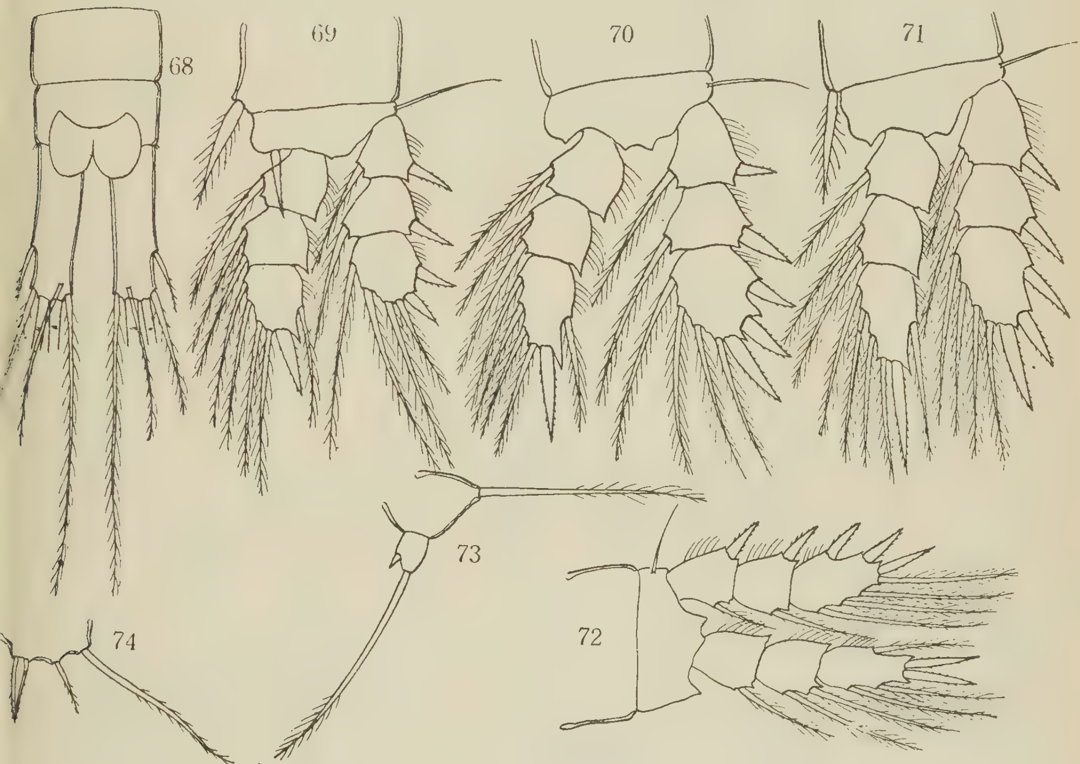
Receptaculum seminis as shown in Fig. 65

Male.—Length 1.40 mm, relatively stout. Body white, without red nauplius eye.

Furcal rami slightly divergent, 3.6 times as long as wide; inner margin without fine hairs; inner furcal seta much longer than the outer (2.6:1), and also

about 3 times as long as furcal rami; outer seta much shorter than the dorsal.

Leg formulal as in female; leg 4, endopodite 3 rather stout, twice as long as wide; terminal spines nearly equal.



Figs. 68–74. *Megacyclops viridis* (JURINE), Male, Hachioji (Tokyo).
68. Furcal rami (dorsal); 69. Leg 1; 70. Leg 2;
71. Leg 3; 72. Leg 4; 73. Leg 5;
74. Leg 6.

Leg 6 of 1 segment, with outer 2 setae and a inner spine; inner spine and median setae nearly equal in length, but outer seta much longer.

Locality.—No. 18 (1♂); No. 39 (1♀); No. 42 (1♀, Copepodid V 2); No. 46 (Copepodid V 1).

9) *Megacyclops viridis takebuensis* n. subsp.

(Figs. 75–80, Table 7)

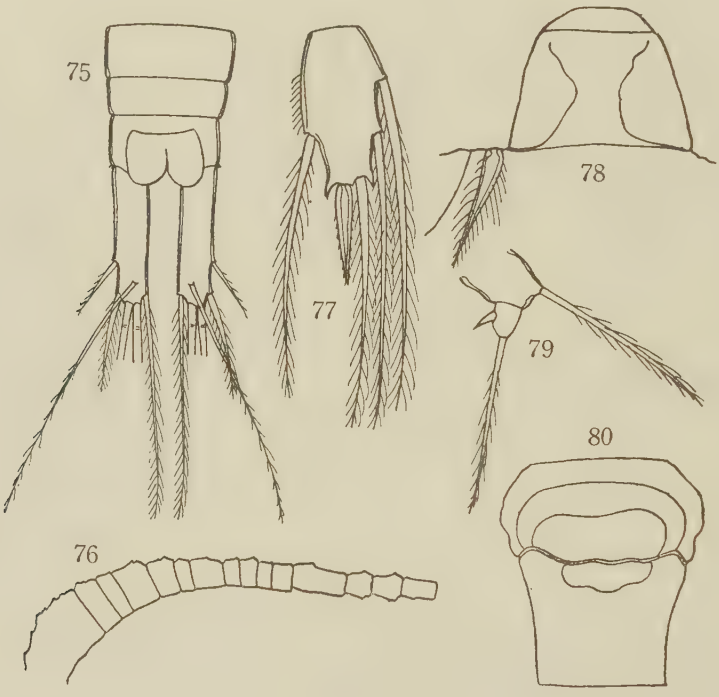
Female.—Length 0.77–0.91 mm. Body white, nauplius eye entirely absent.

Furcal rami nearly parallel, 3.8 times as long as wide; inner margin without hairs; lateral seta inserted at distal 1/3; furcal setae, four terminal and a dorsal, very well-developed, their lengths are from the inner to the outer and the dorsal as follows:

	I (in.)	II	III	IV (ou.)	V (dor.)
Takebu (Fukui)	115.2	209.7	146.3	48	130.2 (μ)

Inner furcal seta much longer than the outer (2.4:1), and longer than ramus; dorsal seta especially well-developed, much longer than the outer, and also slightly longer than the inner one.

First antenna of 15 segments, differing from the typical form, *Megacyclops viridis.*



Figs. 75–80. *Megacyclops viridis takebuensis* n. subsp., Female Takebu (Fukui).

75. Furcal rami (dorsal); 76. First antenna (of 15 segments);
77. Endopodite 3 of leg 4; 78. Connecting plate of leg 4;
79. Leg 5; 80. Receptaculum seminis.

Legs 1–4; as in *M. viridis,* formula 3,3/3,3/3,3/3,3; spine-formula 2,3,3,3; seta-formula 4, 4, 4, 4. Endopodite 3 of leg 4 nearly twice as long as wide (1.8:1); inner terminal spine transformes into an usual seta which is rather long, 69μ in length, and as long as outer marginal seta; outer spine 36μ in length.

The structure of connecting plate of leg 4, receptaculum seminis, as shown in Figs. 78 and 80 respectively, resembling those of *Megacyclops viridis.*

Holotype: female. (loc. No. 33). The type is deposited in the Faculty of Fisheries, Prefectural University of Mie.

Male.—Not found.

Locality.—No. 33 (2♀♀)

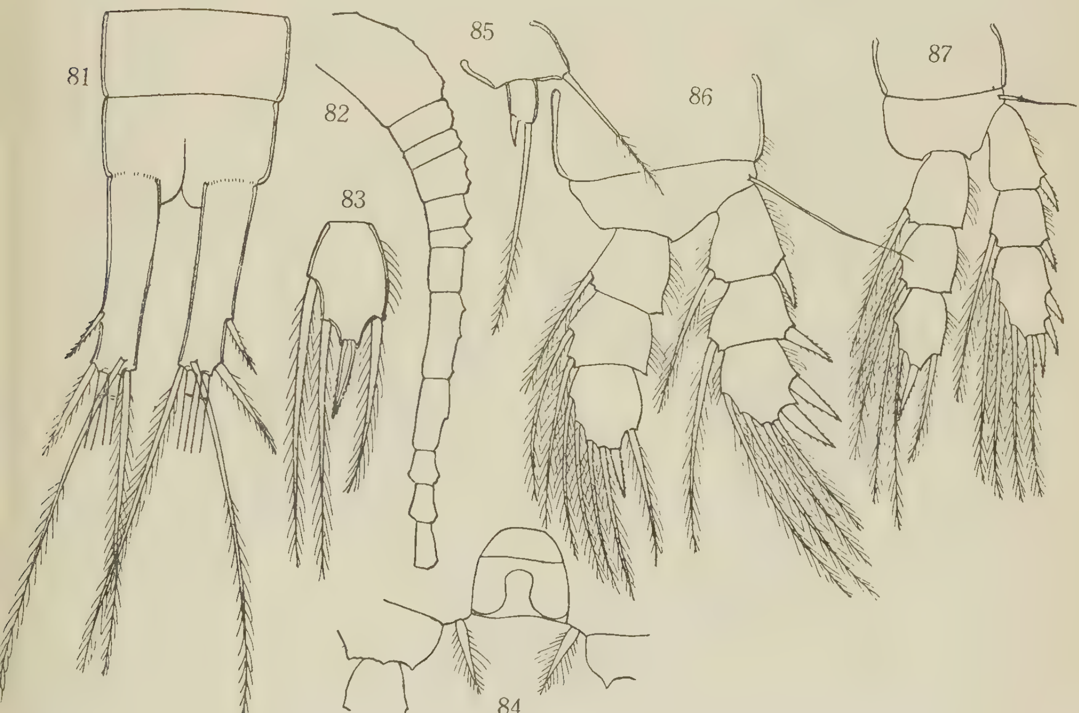
This new subspecies differs from the typical form, *Megacyclops viridis*, in its rather small body, lack of hairs on inner margin of furcal rami, 15-segmented first antenna and the feature of endopodite 3 of leg 4.

10) *Acanthocyclops morimotoi* Ito

(Figs. 81–87, Figs. 88–91; Table 8)

1952, Ito, T., Report of Faculty of Fisheries, Prefectural University of Mie, Vol. 1, No. 2, p. 117, Figs. 8–14.

Female.—Body large and stout, length 1.44 mm. Body white in colour, nauplius eye entirely absent.



Figs. 81–87. *Acanthocyclops morimotoi* Ito, Female, Himeji (Hyogo).
81. Furcal rami (ventral); 82. First antenna;
83. Leg 4, endopodite 3; 84. Connecting plate of leg 4;
85. Leg 5; 86. Leg 1;
87. Leg 4.

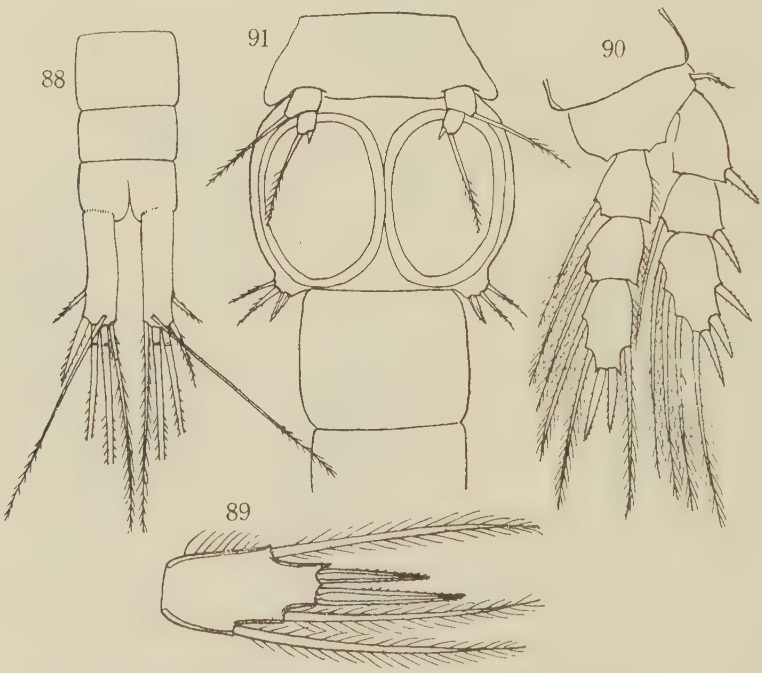
Furcal rami relatively slender, placed wide apart, 5 times as long as wide; inner margin without hairs; lateral seta inserted at distel 1/3; furcal setae, four terminal and a dorsal, remarkably, well-developed, their lengths from the inner to the outer and dorsal as follows:

		I (in.)	II	III	IV (ou.)	V (dor.)
Himeji (Hyogo)	(♀)	202.4	634.8	358.8	64.4	239.2 (μ)
Aioi (Hyogo)	(♂)	150.0	441.6	248.4	52.5	147.2 (μ)

Inner furcal seta much longer than the outer (3.0:1), and longer than furcal rami (1.5:1): dorsal seta especially well-developed, a little longer than the inner, and much longer than the outer (3.7:1) and furcal rami (2:1).

First antenna of 12 segments, without hyaline membrane on distal segments.

Legs 1–4; formula 3,3/3,3/3,3/3,3; spine-formula 2,3,3,3; seta-formula 4,4, 4,4, as in *Diacyclops crassicaudis* (Sars). Endopodite 3 of leg 4 relatively wide, oval in outline, 1.4 times as long as wide, with only one terminal spine, 37.5μ in length and shorter than the segment (75%). Connecting plate of leg 4 simple, as shown in Fig. 84.



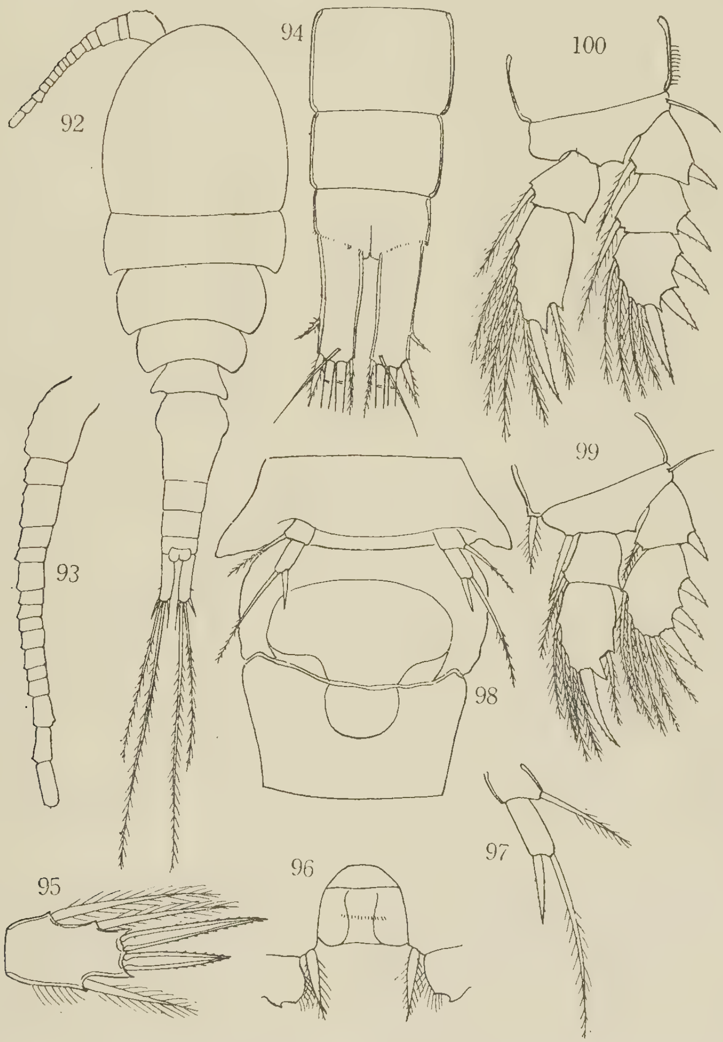
Figs. 88–91. *Acanthocyclops morimotoi* Ito, Male, Aioi (Hyogo).
88. Furcal rami (ventral); 89. Endopodite 3 of leg 4;
90. Leg 4; 91. Leg 5 and leg 6.

Leg 5 of 2 segments; seg. 1 large and broad, with a short slender seta; seg. 2 small and slender, with a short terminal seta and a small subapical spine. Receptaculum seminis not distinct.

Male.—Length 0.91 mm. Body white, without nauplius eys. Furcal rami nearly parallel, 4 times as long as wide; lateral seta inserted at distal 1/3. Both

the inner and dorsal setae much longer than the outer (3.0:1), and longer than furcal rami. Leg 4, endopodite 3 relatively slender, 1.9 times as long as wide; inner apical spine longer than the outer (1.4:1). Leg 5 as shown in Fig. 91. Leg 6, inner spine relatively small, and shorter than 2 outer setae.

Locality.—No. 35 (1♀); No. 36 (1 ♂).



Figs. 92–100. *Diacyclops disjunctus* (THALLWITZ), Himeji (Hyogo).

92. Female, dorsal;
93. First antenna;
94. Furcal rami (ventral);
95. Endopodite 3 of leg 4;
96. Connecting plate of leg 4;
97. Leg 5;
98. Leg 5 and Receptaculum seminis;
99. Leg 1;
100. Leg 2.

11) *Diacyclops disjunctus* (THALLWITZ)
(Figs. 92–100, Figs. 101–111; Table 9)

Female.—Length 0.54–0.95 mm. Body white, nauplius eye entirely absent.

Furcal rami nearly parallel or slightly divergent, relatively short, variable in length, 2.8–3.6 times as long as wide; inner margin whthout hairs; lateral seta inserted at distal 1/3–1/4; lengths of furcal setae, four terminal and a dorsal, are from the inner to the outer and the dorsal as follows:

	I (in.)	II	III	IV (ou.)	V (dor.)	
Kitami-Aioi (Hokkaido)	21	280.8	175.5	30	45	(μ)
〃	18	315.9	187.2	30	45	(μ)
Maiya (Miyagi)	27	304.2	234.0	42	75	(μ)
Takebu (Fukui)	48	404.8	242.0	30	66	(μ)
Ishinden (Mie)	33	379.8	257.4	36	63	(μ)
〃	42	421.2	257.4	39	66	(μ)
〃	33	397.8	245.7	39	60	(μ)
Himeji (Hyogo)	30	441.6	322.0	30	45	(μ)
Aioi (〃)	65	340.4	184.0	32.5	42.5	(μ)
〃	65	331.2	174.8	32.5	45	(μ)
Katsumada (Okayama)	36	404.8	286	39	45	(μ)

Inner furcal seta very variable in length, 0.6–2.0 times as long as the outer; therefore either longer than the outer or as long as, or often shorter than outer one (Kitami-Aioi 0.6–0.7:1; Maiya 0.6–1.0:1; Takebu 1.3–1.6:1; Takebu 0.8:1; Ishinden 0.8–1.1:1; Himeji 1.0–1.9:1; Aioi 2.0:1), and in general shorter than furcal rami, only one individual collected from the well in Aioi-city is slightly longer than the ramus; outer seta shorter than the dorsal one.

First antenna of 16 segments, not reaching to posterior end of cephalothorax, without hyaline membrane on distal segments.

Legs 1–4; formula 2,2/3,2/3,3/3,3; spine-formula 3,3,3,3; seta-formula 5,4,4,4. Leg 4, endopodite 3 relatively short, 1.3–1.7 times as long as wide; terminal spines nearly equal, the inner a little longer (1.0–1.3:1), relative length to the segment very variable (89–136%), but generally equal; inner seta generally not reaching to ends of terminal spines, but 2 outer setae usually extending beyond the ends, or rarely not reaching (Fig. 95). Connecting plate of leg 4 as shown in Fig. 96.

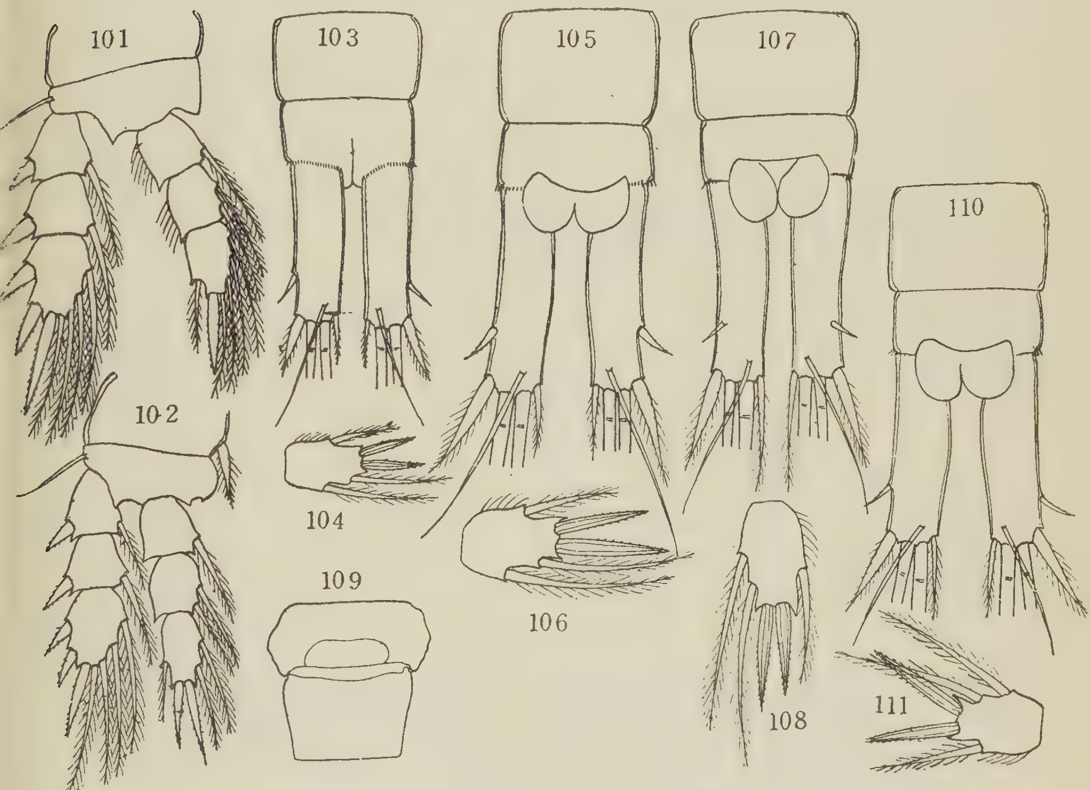
Leg 5: seg. 1 small but wide; seg, 2 slender, with inner spine as long as the segment and placed very near apex.

Receptaculum seminis consisting of a large oval anterior part and a narrower posterior part.

Male.—Length 0.41–0.73 mm. Body white, without nauplius eye as in female. More slender than female,

Fucal rami generally short, 2.8–3.8 times as long as wide; inner furcal seta 0.6–1.6 times as long as the outer; leg formulae as in female; endopodite 3 of leg 4 rather slender, 1.4–1.5 times as long as wide; terminal spine nearly equal, the inner a little longer (1.1–1.4:1), shorter or as long as, or longer than the segment (78–133%).

Locality.—No. 1 (4♀♀, 4♂♂); No. 2 (2♂♂); No. 3 (1♂); No. 13 (1♀, 2♂♂); No. 14 (2♂♂); No. 31 (1♂); No. 32 (2♀♀, 2♂♂); No. 33 (4♀♀, 3♂♂); No. 34 (25♀♀); No. 35 (3♀♀); No. 36 (3♀♀, 1♂); No. 38 (2♀♀, 2♂♂); No. 39 (♀♀, ♂♂); No. 41 (♀♀, ♂♂); No. 43 (2♀♀).



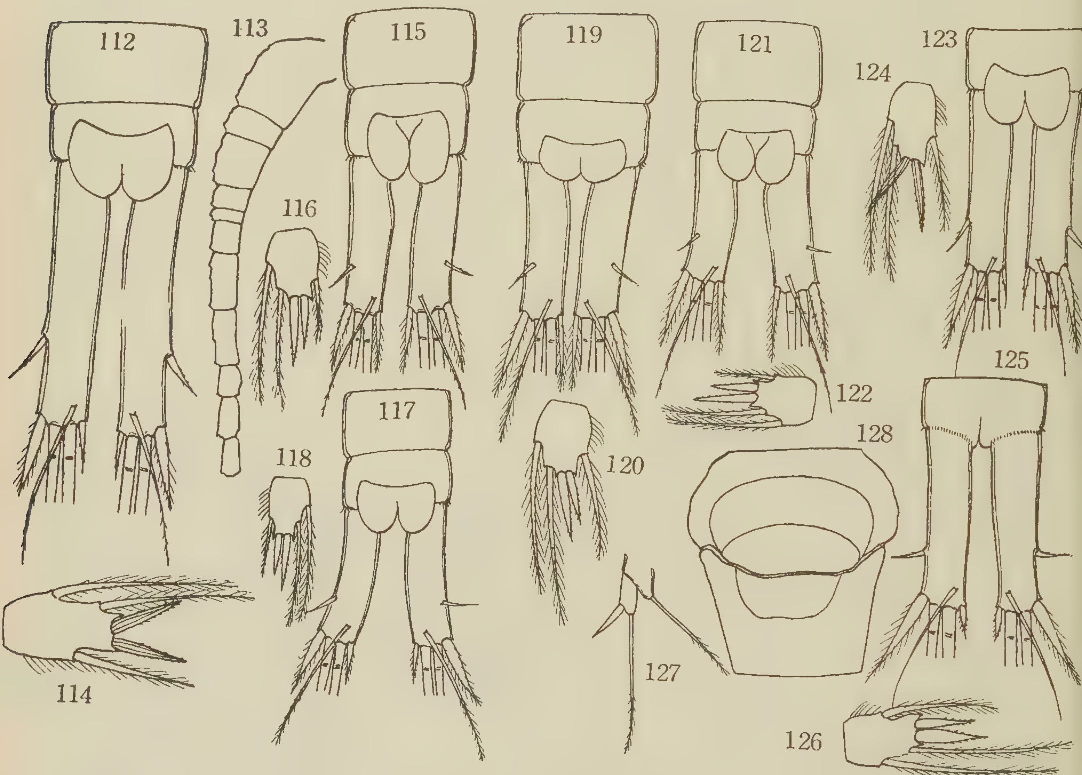
Figs. 101–111. *Diacyclops disjunctus* (THALLWITZ), Female.
101–102. Himeji (Hyogo); 103–104. Kitami-Aioi (Hokkaido);
105–106. Himeji (Hyogo); 107–109. Takebu (Fukui);
110–111. Ishinden (Mie);
101. Leg 3; 102. Leg 4;
103. 105. 107. 110. Furcal rami; 104. 106. 108. 111. Endopodite 3 of leg 4;
109. Receptaculum seminis.

12) *Diacyclops languidoides* (LILLJEBORG)

(Figs. 112–128, Table 10)

Female.—Length rather small, 0.48–0.73 mm. Body white, nauplius eye entirely absent.

Furcal rami relatively shorter than European form, less than 5 times as long as wide, variable in length, 2.6–4.6 times as long as wide; lateral seta inserted at about distal 1/3; inner margin whthout hairs; length of furcal setae, four terminal and a dorsal, are from the inner to the outer and the dorsal as follow:



Figs. 112–128. *Diacyclops languidoides* (Lilljeborg), Female.
112–114. Rikunbetsu (Hokkaido); 115–116. Hachioji (Tokyo);
117–118. Kanazawa (Nagano); 119–120. Enzan (Yamanashi);
121–122. Fukushima (Nagano); 123–124. Takebu (Fukui);
125–128. Furukawa (Gifu).
112. 115. 117. 119. 121. 123. 125. Furcal rami;
114. 116. 118. 120. 122. 124. 126. Endopodite 3 of leg 4;
113. First antenna; 127. Leg 5;
128. Receptaculum seminis.

		I (in.)	II	III	IV (ou.)	V (dor.)
Rikunbetsu (Hokkaido)	(♂)	18	432.9	257.4	30	75 (μ)
Enzan (Yamanashi)	(♀)	33	255.2	162.8	36	60 (μ)
〃	(〃)	24	242	132	30	57 (μ)
〃	(〃)	33	264	158.4	36	69 (μ)
Kanazawa (Nagano)	(〃)	24	233	145	30	60 (μ)
〃	(〃)	24	264	158	24	60 (μ)
Fukushima (Nagano)	(〃)	24	250.8	149.6	24	54 (μ)
Furukawa (Gifu)	(〃)	21	308	215.6	36	54 (μ)
〃	(〃)	21	316.8	211.2	33	51 (μ)

Inner furcal seta very short, generally shorter than the outer or ocassionally as long as (0.5–1.1:1), and much shorter than furcal rami (about 1/2–1/3:1); dorsal seta longer than the outer (about 2:1)

First antenna of 11 segments, not reaching to end of cephalothorax.

Legs 1–4; formula 2,2/3,2/3,3/3,3; spine-formula 3,3,3,3; seta-formula 5,4, 4,4, identical with that of *Diacyclops disjunctus*. Leg 4, endopodite 3 variable in length, 1.0–1.8 times as long as wide; terminal spines nearly equal in length; the inner a little longer (1.0–1.4:1), and nearly as long as the segments (78–129%).

The forms of leg 5 and receptaculum seminis as shown in Figs. 127 and 128 respectively.

Male.—Length 0.45–0.74 mm. Body white, without nauplius eye as in female. Furcal rami 2.4–5.2 times as long as wide; inner furcal seta generally shorter than the outer (0.6–1.0:1). Endopodite 3 of leg 4 rather slender, 1.2–1.9 time as long as wide; terminal spines nearly equal, the inner a little longer (1.0–1.4:1), and longer than the segment (100–117%); but in an animal collected from Rikunbetsu (Hokkaido) shorter than endopodite 3, (54%).

Locality.—No. 2 (1♀, 1♂); No. 8 (2♀♀); No. 18 (1♀); No. 23 (6♀♀, 5♂♂); No. 25 (17♀♀, 4♂♂); No. 26 (3♀♀, 2♂♂); No. 27 (10♀♀, 2♂♂); No. 28 (4♀♀); No 33 (13♀♀, 3♂♂).

13) *Diacyclops languidoides japanicus* Ito

(Figs. 129–137, Figs. 138–143; Table 11)

1952, Ito, T., Report of Faculty of Fisheries, Prefectural University of Mie, Vol. 1, No. 2, p. 118, Figs. 15–21.

Female.—Length 0.63–0.75 mm. [Hachioji (Tokyo) 0.75 mm; Himeji (Hyogo) 0.72–0.75 mm; Aioi (Hyogo) 0.63–0.75 mm.], or occasionally 1.07–1.10 mm. (Taishi, Hyogo). Body white, nauplius eye entirely absent.

Furcal rami variable in length, 3.0–5.2 times as long as wide (Hachioji 3.0:1; Himeji: 3.6–4.0:1; Aioi 3.9–5.2:1); lateral seta inserted at distal 1/4; inner margin without hairs; furcal setae, four terminal and a dorsal, well-developed, length from the inner to the outer and the dorsal as follows:

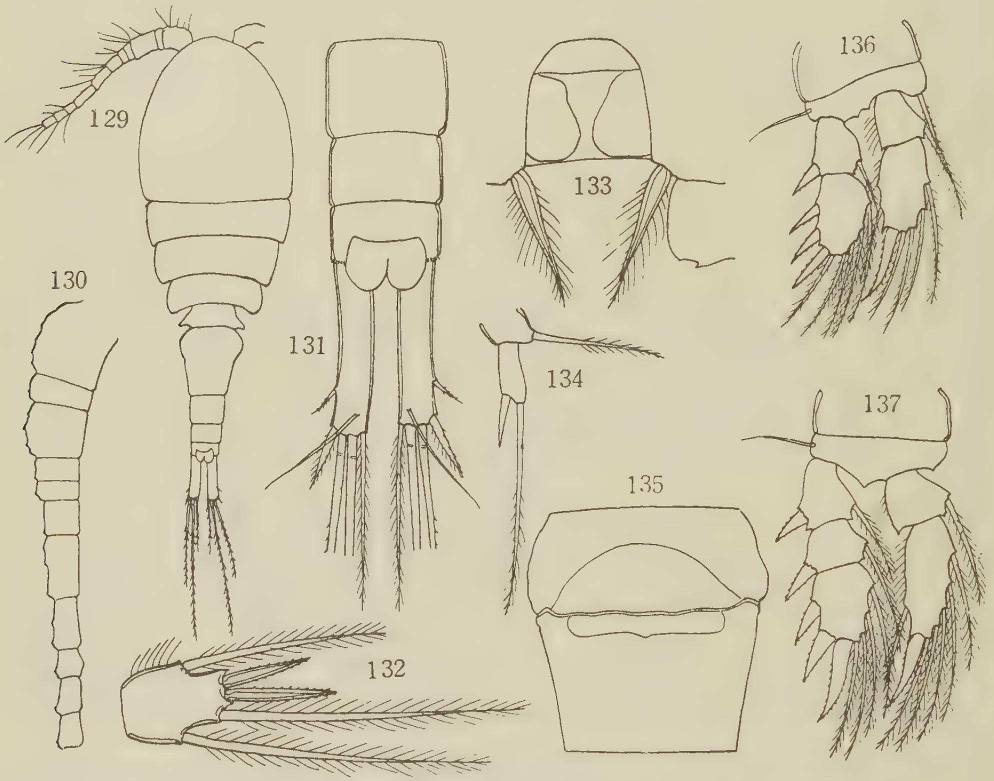
	I (in.)	II	III	IV (ou.)	V (dor.)
Hachioji (Tokyo)	69	330	176	30	60 (μ)
Himeji (Hyogo)	87.5	377.2	220.8	35	46 (μ)
Aioi (〃)	85	322	220.8	32.5	55 (μ)
〃	105	450.8	239.2	40	67.5 (μ)

Inner furcal seta remarkably longer than the outer (2.3–3.0:1), and much longer than furcal rami (1.3–1.6:1); dorsal seta longer than the outer.

First antenna of 11 segments, rather short, not reaching to posterior end of cephalothorax.

Legs 1–4; formula 2,2/3,2/3,3/3,3; spine-formula 3,3,3,3; seta-formula 5,4,

4,4. Leg 4, endopodite 3, rather slender, 1.4–1.6 timesas long as wide; terminal spines nearly equal in length, the inner a little longer (Hachioji 1.1:1; Himeji 1.1–1.2:1; Aioi 1.1–1.2:1; 1.1:1) and slightly shorter than the segment (73–105%); 3 setae well developed, extending far beyond ends of terminal spines; connecting plate of leg 4 as shown in Fig. 133.



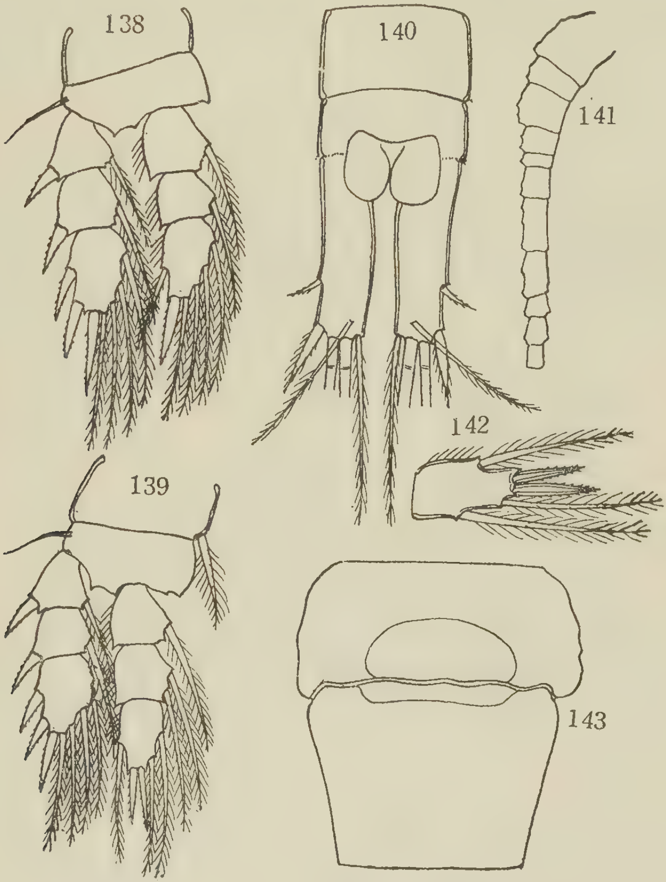
Figs. 129–137. *Diacyclops languidoides japicicus* Ito, Female Himeji (Hyogo).
129. Female, dorsal; 130. First antenna;
131. Furcal rami (dorsal); 132. Endopodite 3 of leg 4;
133. Connecting plate of leg 4; 134. Leg 5;
135. Receptaculum seminis; 136. Leg 1;
137. Leg 2.

The structure of leg 5 and receptaculum seminis as shown in Fig. 134 and Fig. 135 respectively.

Male.—Length 0.59–0.68 mm., or occasionally 0.84–0.88 mm. More slender than female. Body white, without nauplius eye as in female. Furcal rami rather slender, 3.7–5.2 times as long as wide; inner furcal seta much longer than the outer (2.3–2.9:1), and longer than furca. Leg formulae as in female.

Locality.—No. 19 (1♀); No. 35 (2♀♀, 2♂♂); No. 36 (7♀♀, 15♂♂); No. 38 (11♀♀, 8♂♂); No. 39 (♀♀, ♂♂); No. 41 (♀♀, ♂♂); No. 42 (13♀♀, 11♂♂).

This subspecies differs from the typical form, *Diacyclops languidoides* (LILLJEBORG) in having a rather longer inner furcal seta.



Figs. 138–143. *Diacyclops languidoides japonicus* ITO. Female.
138–139. Himeji (Hyogo); 140–143. Hachioji (Tokyo);
138. Leg 3; 139. Leg 4;
140. Furcal rami (dorsal); 141. First antenna;
142. Leg 4, endopodite 3; 143. Receptaculum sminis.

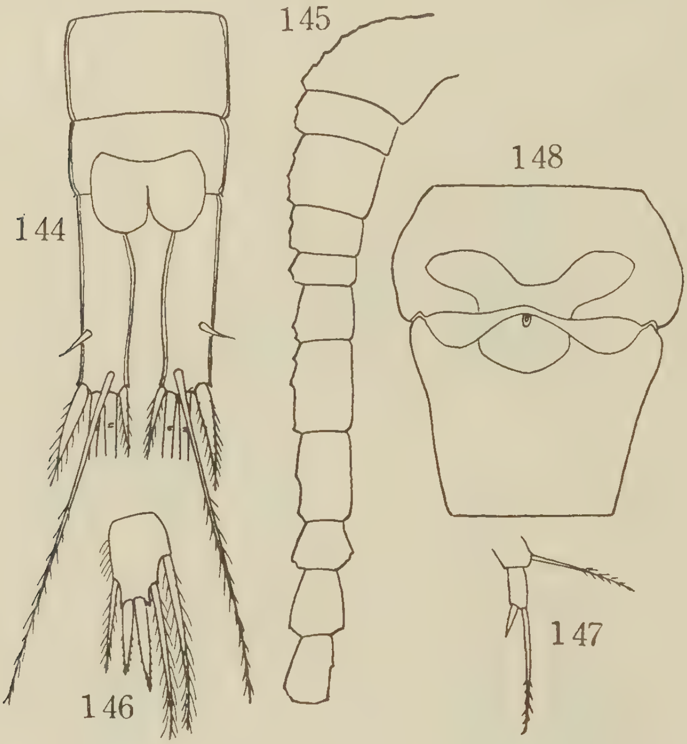
14) *Diacyclops languidoides suoensis* n. subsp.
(Figs. 114–148, Table 12)

Female.—Length 0.59–0.71 mm. Body white, without nauplius eye.

Furcal rami relatively short, 3.1–3.8 time as long as wide; lateral seta inserted at distal 1/3; inner margin without hairs; length of furcal setae is from the inner to the outer and the dorsal as follows;

	I (in.)	II	III	IV (ou.)	V (dor.)
Tonda (Yamaguchi)	21	237.6	132	27	120 (μ)

Inner furcal seta rather small, shorter than the outer, or as long as (0.8–1.0:1) and shorter than ramus (about 1/2:1); dorsal seta remarkably long and plumose, much longer than ramus (about 2:1). and as long as outer median furcal seta.



Figs. 144–148. *Diacyclops languidoides suoensis* n. subsp., Female, Tonda (Yamaguchi).
144. Furcal rami (dorsal); 145. First antenna; 146. Endopodite 3 of leg 4; 147. Leg 5; 148. Receptaculum seminis.

First antenna of 11 segments, not reaching to end of cephalothorax as in the former two forms.

Legs 1–4; formula 2,2/3,2/3,3/3,3; spine-formula 3,3,3,3; seta-formula 5,4,4,4, as in the former two species. Endopodite of leg 4 rather slender, 1.3–1.6 times as long as wide; inner terminal spine slightly longer than the outer (1.1–1.3:1), and longer than the segment, or as long as (100–133%). Receptaculum seminis characteristic, and shown in Fig. 148.

Leg 5 agrees well with that of *Diacyclops languidoides*, *D. l. japonicus* and *D. disjunctus*, (Fig. 147).

Holotype; female (loc. No 46), the type is deposited in the Faculty of Fisheries, Prefectural University of Mie.

Male.—Not found.

Locality.—No. 46 (2♀♀).

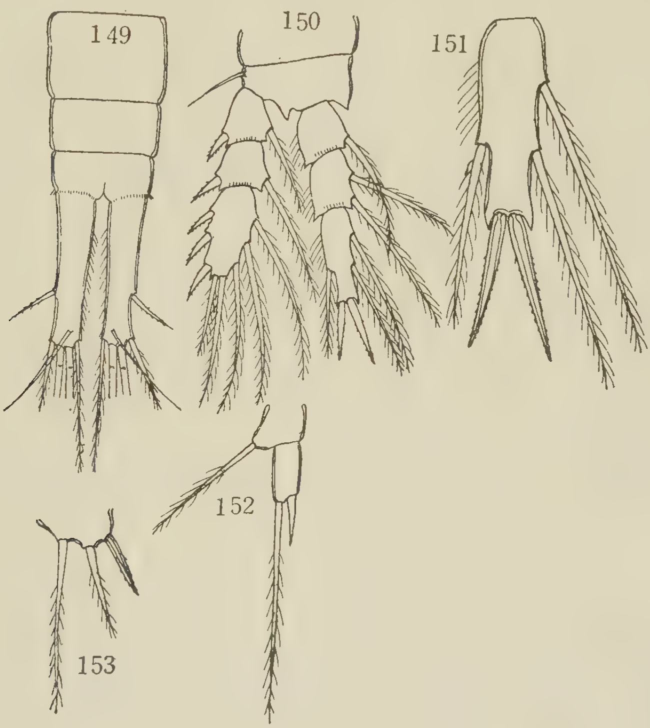
This new subspecies differs from both *Diacyclops languidoides* and *D. languidoides japonicus* in regard to well-developed dorsal seta of furca and receptaculum seminis.

15) *Diacyclops* sp.

(Figs. 149–153; Table 13)

Male.—Body length 1.07 mm. Body white, nauplius eye entirely absent.

Furcal rami rather slender, 4.9 times as long as wide; inner margin with hairs; lateral seta located at distal 1/3, length of furcal setae is from the inner to the outer and the dorsal as follows:



Figs. 149–153. *Diacyclaps sp.*, Male, Kitami-Aioi (Hokkaido).
149. Furcal rami (ventral); 150. Leg 4;
151. Endopodite 3 of leg 4; 152. Leg 5;
153. Leg 6.

	I (in.)	II	III	IV (ou.)	V (dor.)
Kitami-Aioi (Hokkaido)	108	514.8	327.6	90	81 (μ)

Inner furcal seta scarcely longer than the outer (1.2:1), and shorter than the ramus; dorsal seta slightly shorter than the outer.

Legs 1–4; formula 3,3/3,3/3,3/3,3; spine-formula 3,4,4,3; seta-formula 4,4, 4,5. Endopodite 3 of leg 4 very long and slender, 2.9 times as long as wide; terminal spines nearly equal, the inner a little the longer (1.3:1), and shorter than the segment (87%).

The structure of leg 5 agrees with that of the genus *Diacyclops*.

Leg 6 as shown in Fig. 153, with a inner spine and two outer setae; the outer-most seta longest.

Female.—Unknown.

Locality.—No. 1 (1♂).

The specimen collected from a well at Kitami-Aioi (Hokkaido) is very peculiar. The form of leg 5 resembles that of *Diacyclops* but the leg formulae very characteristic. Owing to the lack of female specimen, it is better to reserve at present the determination of specific trivial name.

16) *Microcyclops* (*Microcyclops*) *varicans* (SARS)
(Figs. 154–162; Table 14)

Female.—Length 1.44 mm. (larger than European form). Body white, nauplius eye entirely absent.

Furcal rami nearly parallel, 4.2 times as long as wide; lateral seta inserted at distal 1/3, inner margin without hairs; length of furcal setae from the inner to the outer and dorsal as follows:

	I (in.)	II	III	IV (ou.)	V (dor.)
Kanazawa (Nagano)	63	308	220	39	45 (μ)

Inner furcal seta much longer than the outer (1.6:1), and as long as furcal rami; dorsal seta slightly longer than outer.

First antenna of 11 segments, not reaching to end of cephalothorax.

Legs 1–4; formula 2,2/2,2/2,2/2,2; spine-formula 3,4,4,3; seta-formula 5,5,5,5.

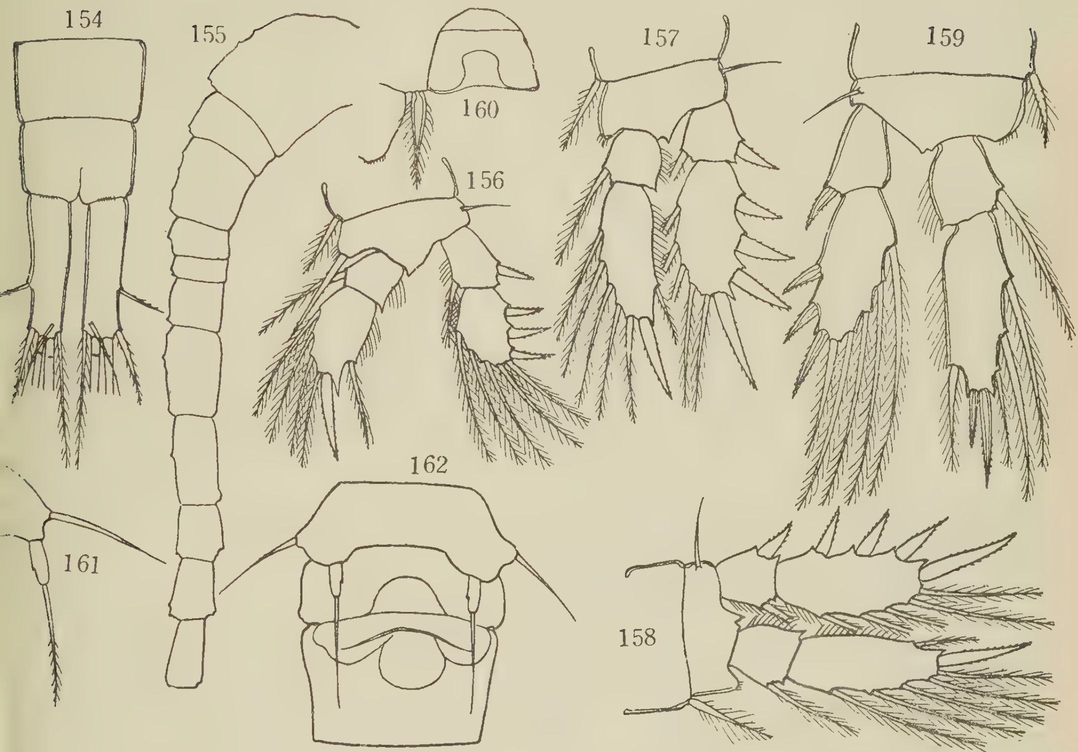
Leg 4, exopodite 1 without inner seta; endopodite 2 rather slender, with 3 setae on inner side and a single seta on outer side, 2.6 times as long as wide; terminal spines unequal in length, inner spine much longer than the outer (1.5:1), but much shorter than the segment (57%).

Leg 5; seg. 1 fused with thoracic segment 5, its seta inserted on outer angle of the latter; seg. 2 small and cylindrical, with one apical seta and a single very small inner spinule.

Connecting plate of leg 4 as shown in Fig. 160. Receptaculum seminis with anterior and posterior parts nearly similar in shape (Fig. 162).

Male.—Unknown.

Locality.—No. 24 (1♀)



Figs. 154–162. *Microcyclops (Microcyclops) varicans* (SARS), Female; Kanazawa (Nagano).

154. Furcal rami (ventral);
155. First antenna (11 segmented);
156. Leg 1;
157. Leg 2;
158. Leg 3;
159. Leg 4;
160. Connecting plate of leg 4;
161. Leg 5;
162. Leg 5 and Receptaculum seminis.

17) *Mesocyclops leuckarti* (CLAUS)

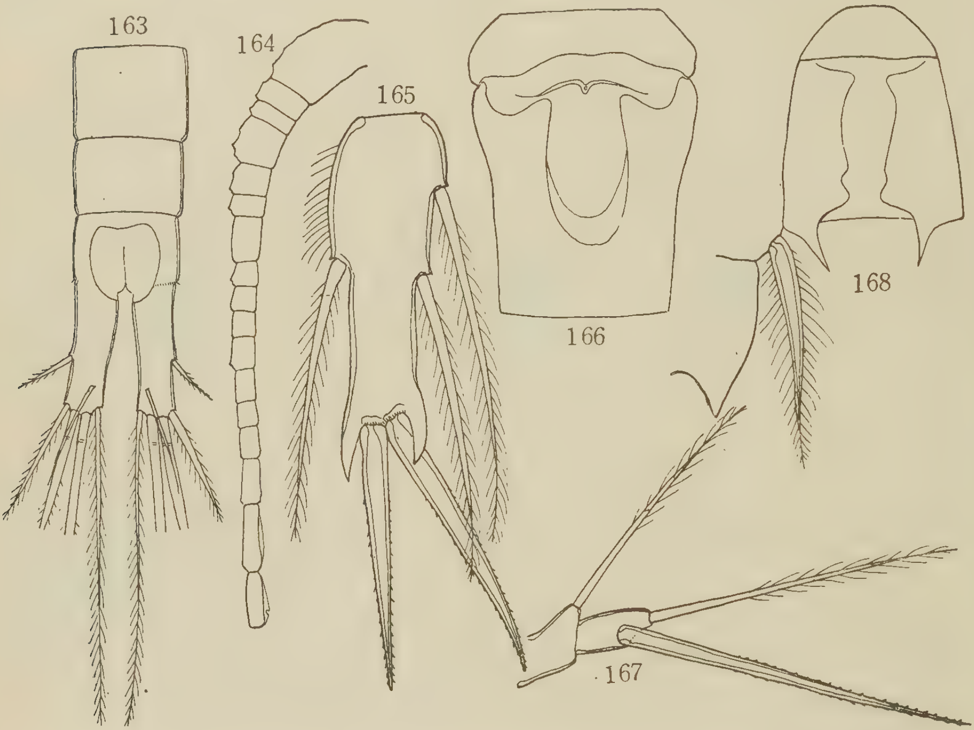
(Figs. 163–168; Table 15)

Female.—Length very variable, 0.85–1.71 mm, [the limestone cave Shuhodo, 1.48–1.71 mm., a well at Masuda (Shimane) 0.85–0.88 mm.]. Body brownish yellow; without nauplius eye.

Furcal rami relatively short, 3.2–3.6 times as long as wide; lateral seta inserted at distal 1/2.5; inner margin without hairs; furcal setae well developed, their lengths from the inner to the outer and dorsal as follows:

	I (in.)	II	III	IV (ou.)	V (dor.)	
Shuhodo (a limestone cave, Yamaguchi)	277.2	638.0	462.0	96.8	88	(μ)
〃	286.0	629.2	453.2	96.8	92.4	(μ)
〃	308.0	660.0	484.0	127.6	114.4	(μ)
〃	321.2	686.4	488.4	127.6	118.8	(μ)

Inner furcal seta much longer than the outer (2.4–3.0:1), and also much longer than furca (2.2–2.7:1); the outer slightly longer than the dorsal.



Figs. 163–168. *Mesocyclops leuckarti* (CLAUS), Female, Cave Shuhodo (Yamaguchi).
163. Furcul rami (dorsal); 164. First antenna;
165. Endopodite 3 of leg 4; 166. Receptaculum seminis;
167. Leg 5; 168. Connecting plate of leg 4.

First antenna of 17 segments, reaching to end of somite 2; last 2 segments with a broad hyaline membrane. Membrane of seg. 17 more coarsely serrated. Leg 1—leg 4; formula 3,3/3,3/3,3/3,3; spine-formula 2.3,3,3; seta-formula 4,4,4,4. Leg 4, endopodite 3 rather slender, 2.5–3.0 times as long as wide; 3 setae not reaching to ends of apical spines; terminal spines nearly equal, the inner a little longer (1.0–1.1:1), and apical spines nearly as long as the segment (85–103%).

Connecting plate of leg 4 with a pair of pointed spine-like processes. (Fig. 168)

Leg 5, seg. 2 slender, with long apical seta, and long inner spine inserted near apex, and nearly as long as apical seta.

Receptaculum seminis T-shaped, consisting of a long narrow posterior sac which reaches nearly to end of genitial segment, and a transverse anterior part, not recurved. (Fig. 166)

Male.—Unknown.

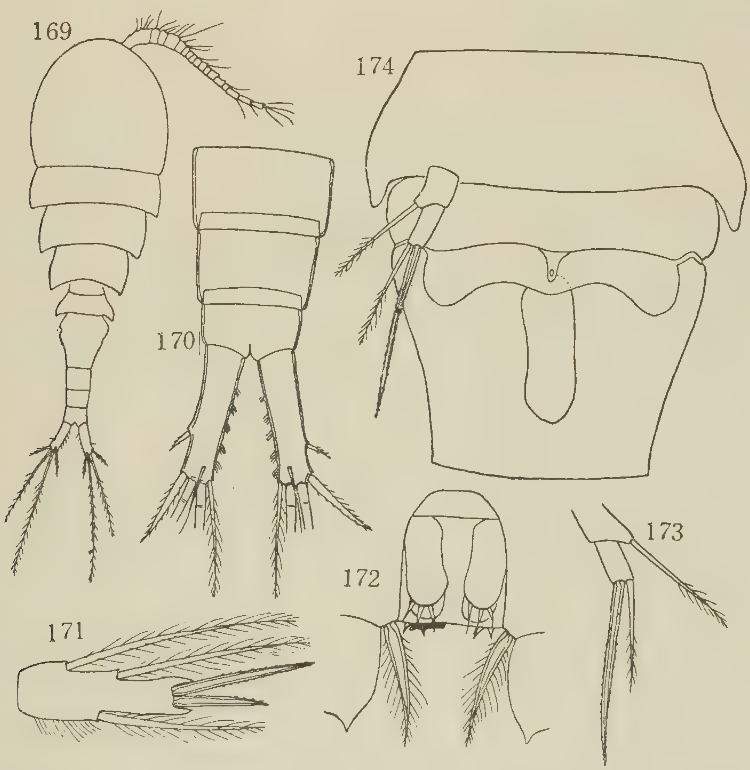
Locality.—No. 45 (well, 2 ♀♀); No. 48 (limestone cave, ♀ and Copepodid abundant).

18) *Thermocyclops uênoi* Ito

(Figs. 169–174; Table 16)

1952, Ito, T., Report of Faculty of Fisheries, Prefectural University of Mie, Vol. 1, No. 2, p. 119, Figs. 22–25.

Female.—Length 0.75–1.20 mm. Body white, with distinct red nauplius eye. Furcal rami remarkably divergent, 3.5–4.6 times as long as wide; inner margin with 4–5 bundles of fine hairs; lateral seta inserted at distal 1/3; inner furcal seta much longer than the outer (1.3–1.8:1), and usually shorter than furcal rami.



Figs. 169–174. *Thermocyclops uênoi* Ito, Female, Sashiki (Kumamoto).
169. Female, dorsal; 170. Furcal rami;
171. Endopodite 3 of leg 4; 172. Connecting plate of leg 4;
173. Leg 5; 174. Leg 5 and Receptaculum seminis.

First antenna of 17 segments, relatively short, reaching to the posterior end of body somite 2; without hyaline membrane on distal segments.

Legs 1–4; formula 3,3/3,3/3,3/3,3; spine-formula 2,3,3,3; seta-formula 4,4, 4,4,. Endopodite 3 of leg 4 rather slender, 2.0–2.7 times as long as wide; terminal spines unequal, the inner much longer than the outer (1.4–1.8:1), but shorter than the segment (88–95%). Connecting plate of leg 4 characteristic, with 3 pairs of rounded prominences, 3 slender spines on anterior and 2 small, stout processes on top of posterior prominence respectively, but none of appendages on top of middle. (Fig. 172)

Leg 5 of 2 segments, seg. 2 rather slender; about twice as long as wide, with inner spine and apical seta, the inner spines much longer than the outer seta, inserted quite apically.

Receptaculum seminis hammer-shaped, the lateral anterior part not recurved; resembling that of *Thermocylops hyalinus* (Rehberg), but lateral part rather broader than in the latter.

Male.—Length 0.86 mm.

Locality.—No. 49 (7♀♀, 1♂)

19) *Speocyclops yezoensis* n. sp.
(Figs. 175–180, Table 17)

Female.—Length 0.211+0.152 mm., 0.36 mm. Body rather flattened, white in colour, nauplius eye entirely absent; thoracic somites 4 and 5 scarcely broader than genitial segment, so that thorax is not sharply marked off from abdomen as in Harpacicoid-Copepoda. Abdomen consisting of 4 segments; genitial segment with a pair of protuberance on lateral sides. Anal operculum very large, trianglar, without teeth on margin. Posterior end of anal segment with transversely arranged spinules on ventral side.

Furcal rami slightly divergent, very short, 1.3 times as long as wide; lateral seta spine-like, inserted at distal 1/3; inner margin without hairs; furcal seta as in other Cyclopoid-Copepoda, their length from the inner to the outer and dorsal as follows:

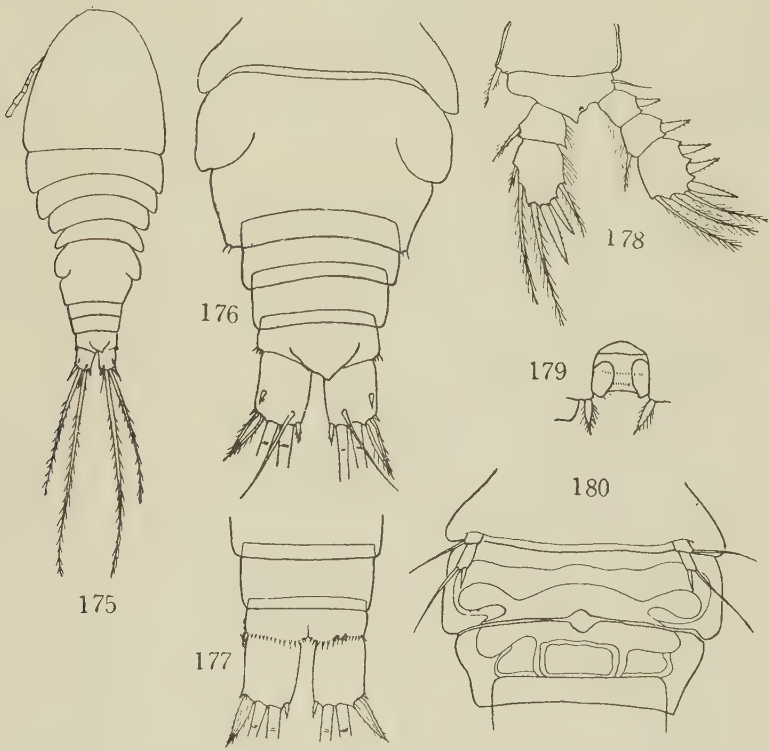
	I (in.)	II	III	IV (ou.)	V (dor.)
Samani (Hokkaido)	9	351	140.4	18	33 (μ)

the inner, outer and dorsal furcal setae very small and short, the inner seta re markably shorter than the outer (1/2:1), and also shorter than the ramus (1/3:1); dorsal seta longer than the outer and the ramus.

First antenna of 11 segments, very short, not reaching to end of cephalothorax.

Legs 1–4; formula 2,2/2,2/3,2/3,2; spine-formula 3,4,3,3; seta-formula 4,3, 4,3. Leg 4, exopodite 1 without seta on inner side; endopodite 1 with a seta on

inner margin, endopodite 2 relatively short, 1.2 times as long as wide, with a seta on outer side and 3 seta on inner margin, proximal inner seta very small and short, but other 2 distal setae well-developed, extending beyond ends of terminal spines; terminal spines unequal in length, the inner longer than the outer (1.6:1) and also longer than the segment (114%). Connecting plate of leg 4 as shown in Fig. 179.



Figs. 175-180. *Speocyclops yezoensis* n. sp., Female Samani (Hokkaido).
175. Female, dorsal; 175. Abdomen and Furcal rami (dorsal);
177. Furcal rami (ventral); 178. Leg 4;
179. Connecting plate of leg 4; 180. Leg and Receptaculum seminis.

Leg 5 of distinctly 2 segments, resembling that of the genus *Diacyclops*, differing from European cave-inhabiting species belongs to the genus *Speocyclops* (Kiefer, 1934 b). (Fig. 180)

Receptaculum seminis very complicated, as shown in Fig. 180.

Holotype: female (loc. No. 5); 1♀ (loc. No. 6). The type is deposited in the Faculty of Fisheries, Prefectural University of Mie.

Male.—Unknown.

Locality.—No. 5 (1♀); No. 6 (1♀)

Leg 5 of this new species evidently consisting of 2 segments, differing from

the European species belongs to the genus *Speocyclops*, rather resembles that of the genus *Diacyclops*; but other forms of body generally identical with that of *Speocyclops*. This new species also evidently distinguishable from the European cave-inhabiting species by the structure of furca, leg formulae and receptaculum seminis.

Summary

Up to the present date, the following 19 forms referable to 12 genera which belong to Copepoda-Cycylopoida have been reported and described from the subterranean waters of Japan.

a) Wells with pump

1) *Macrocyclops fuscus* (JURINE)
2) *Macrocyclops albidus* (JURINE)
3) *Eucyclops serrulatus* (FISCHER)
4) *Eucyclops miurai* ITO
5) *Tropocyclops prasinus* (FISCHER)
6) *Paracyclops fimbriatus* (FISCHER)
7) *Cyclops vicinus* ULJANIN ?
8) *Megacyclops viridis* (JURINE)
9) *Megacyclops viridis takebuensis* n. subsp.
10) *Acanthocyclops morimotoi* ITO
11) *Diacyclops disjunctus* (THALLWITZ)
12) *Diacyclops languidoides* (LILLJEBORG)
13) *Diacyclops languidoides janonicus* ITO
14) *Diacyclops languidoides suoensis* n. subsp.
15) *Diacyclops* sp.
16) *Microcyclops* (*Microcyclops*) *varicans* (SARS)
17) *Mesocyclops leuckarti* (CLAUS)
18) *Thermocyclops uénoi* ITO
19) *Speocyclops yezoensis* n. sp.

b) Subterranean pool in a cave

1) *Mesocyclops leuckarti* (CLAUS)
2) *Eucyclops serrulatus* (FISCHER). (UÉNO, 1934a, as *Eucyclops nagasakai*; IDE, 1935, as *Cyclops serrulatus* FISCHER)

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Appendix: Tables of Measurements

Table 1 *Macrocyclops fuscus* (JURINE)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 1.836	114:48=2.4:1	421.2:257.4=1.6:1	120:39=3.1:1	75:117=0.6:1	No. 10
♀ 1.764	114:48=2.4:1	397.8:245.7=1.6:1	135:42=3.2:1	81:117=0.7:1	〃
♀ 1.890	129:51=2.5:1	444.6:280.8=1.6:1	105:36=2.9:1	75:114=0.7:1	No. 14

Table 2 *Eucyclops serrulatus* (FISCHER)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 0.971	144:25.5=5.6:1	102:72=1.4:1	69:30=2.3:1	75:51=1.5:1	No. 5
♀ 0.913	141:24=5.9:1	93:63=1.5:1	63:27=2.3:1	63:48=1.3:1	〃
♂ 0.784	72:21=3.2:1	90:42=2.1:1	48:18=2.7:1	45:33=1.4:1	〃
♀ 1.193	135:28.5=4.7:1	93:66=1.4:1	66:24=2.8:1	69:57=1.2:1	No. 9
♀ 1.018	114:27=4.2:1	81:66=1.2:1	63:24=2.6:1	63:48=1.3:1	〃
♀ 0.995	102:27=3.8:1	90:60=1.5:1	57:24=2.4:1	57:45=1.3:1	〃
♀ 0.983	96:24=4.0:1	78:54=1.4:1	54:21=2.6:1	54:39=1.4:1	〃
♂ 0.761	69:21=3.3:1	66:42=1.6:1	48:18=2.7:1	51:39=1.3:1	〃
♀ 1.076	126:25.5=4.9:1	96:81=1.2:1	63:27=2.3:1	69:51=1.4:1	No. 10
♀ 1.018	129:22.5=5.7:1	75:60=1.3:1	54:24=2.3:1	66:45=1.5:1	〃
♂ 0.772	78:19.5=4.0:1	54:36=1.5:1	45:15=3.0:1	57:39=1.5:1	〃
♀ 1.088	102:24=4.3:1	75:57=1.3:1	60:30=2.0:1	69:58.5=1.2:1	No. 14
♂ 0.784	72:21=3.4:1	75:45=1.7:1	51:21=2.4:1	51:39=1.3:1	〃
♀ 1.098	105:27=3.9:1	90:60=1.5:1	57:24=2.4:1	57:45=1.3:1	No. 24
♀ 0.948	105:20=5.3:1	75:52.5=1.4:1	52.5:22.5=2.3:1	57.5:42.5=1.4:1	No. 36
♀ 0.902	105:22.5=4.7:1	72.5:55=1.3:1	52.5:22.5=2.3:1	62.5:45=1.4:1	〃
♀ 0.892	90:20=4.5:1	75:52.5=1.4:1	52.5:22.5=2.3:1	55:40=1.4:1	〃
♀ 0.809	90:20=4.5:1	77.5:52.5=1.5:1	50:20=2.5:1	55:40=1.4:1	〃
♂ 0.791	70:17.5=4.0:1	67.5:40=1.7:1	45:17.5=2.6:1	47.5:37.5=1.3:1	〃
♀ 0.959	99:21=4.7:1	90:72=1.3:1	48:27=1.8:1	54:36=1.5:1	No. 45
♀ 1.135	126:27=4.7:1	90:78=1.2:1	66:27=2.4:1	66:54=1.2:1	No. 47
♀ 1.105	105:24=4.4:1	69:60=1.2:1	51:24=2.1:1	54:39=1.4:1	No. 49
♀ 1.105	96:24=4.0:1	51:39=1.3:1	53:21=1.6:1	33:27=1.2:1	〃
♀ 1.000	114:24=4.8:1	69:48=1.4:1	57:24=2.4:1	48:39=1.2:1	〃
♀ 1.120	135:30=4.5:1	78:69=1.1:1	63:27=2.3:1	60:51=1.2:1	〃

Table 3 *Eucyclops miurai* ITO

Body-Length mm.	Furca Len.: Bre. (μ)	Furcal Setae in.: ou. (μ)	Leg 4, endopod 3 Len.: Bre. (μ)	Leg 4, endopod 3, spines in.: ou. (μ)	Locality
♂ 0.936	90:18=5.0:1	117:45=2.6:1	45:18=2.5:1	51:30=1.7:1	No. 4
♀ 0.784*	78:22.5=3.5:1	66:39=1.7:1	45:21=2.1:1	36:30=1.2:1	No. 8
♀ 0.842	105:27=3.9:1	51:24=2.1:1	51:22.5=2.3:1	54:39=1.4:1	No. 11
♀ 0.878	96:24=4.0:1	63:45=1.4:1	51:21=2.4:1	54:42=1.3:1	〃
♀ 0.854	105:27=3.9:1	54:39=1.4:1	51:21=2.4:1	57:39=1.5:1	No. 12
♀ 0.807	99:24=4.1:1	60:45=1:3:1	54:21=2.6:1	57:39=1.5:1	〃
♀ 0.866	84:27=3.1:1	81:45=1.8:1	51:25.5=2.0:1	45:36=1.3:1	No. 14
♀ 0.796**	75:18=4.2:1	105:45=2.3:1	42:24=1.8:1	42:30=1.4:1	No. 20
♀ 0.714	78:18=4.3:1	90:36=2.5:1	45:18=2.5:1	45:27=1.7:1	No. 21
♀ 0.655	72:21=3.4:1	78:33=2.4:1	42:18=2.3:1	42:24=1.8:1	〃
♂ 0.644	63:18=3.5:1	75:33=2.3:1	36:18=2.0:1	39:24=1.6:1	〃
♀ 0.831	75:19.5=3.8:1	99:45=2.2:1	51:21=2.4:1	48:42=1.2:1	No. 32
♀ 0.889	114:24=4.8:1	93:48=1.9:1	51:21=2.4:1	54:45=1.2:1	No. 33
♀ 0.866	81:21=3.9:1	108:48=2.3:1	48:21=2.3:1	51:42=1.2:1	〃
♀ 0.856	95:17.5=5.4:1	100:42.5=2.4:1	42.5:17.5=2.4:1	50:30=1.7:1	No. 35
♀ 0.828	90:20=4.5:1	102.5:42.5=2.4:1	40:20=2.0:1	50:27.5=1.8:1	〃
♀ 0.782	85:16.3=5.2:1	67.5:30=2.3:1	40:20=2.0:1	42.5:27.5=1.5:1	〃
♀ 0.708	70:15=4.7:1	100:37.5=2.7:1	40:15=2.7:1	40:22.5=1.8:1	〃
♀ 0.736	85:17.5=4.9:1	100:40=2.5:1	37.5:17.5=2.1:1	37.5:22.5=1.7:1	〃
♀ 0.653	82.5:15=5.5:1	77.5:32.5=2.4:1	40:20=2.0:1	47.5:30=1.6:1	〃
♂ 0.653	70:15=4.7:1	85:30=2.8:1	35:15=2.3:1	40:22.5=1.8:1	〃
♂ 0.644	67.5:15=4.5:1	70:32.5=2.2:1	37.5:17.5=2.2:1	37.5:22.5=1.7:1	〃
♂ 0.626	67.5:15=4.5:1	80:27.5=2.9:1	37.5:17.5=2.2:1	40:25=1.6:1	〃
♂ 0.534	52.5:12.5=4.2:1	80:25=3.2:1	32.5:17.5=1.9:1	35:20=1.8:1	〃
♀ 0.672	70:15=4.7:1	100:37.5=2.7:1	40:15=2.7:1	40:20=2.0:1	No. 36
♂ 0.681	62.5:17.5=3.6:1	62.5:30=2.1:1	42.5:15=2.8:1	42.5:33=1.2:1	〃
♂ 0.690	72.5:15=4.8:1	80:22.5=3.6:1	37.5:17.5=2.2:1	40:32.5=1.2:1	〃
♂ 0.672	52.5:17.5=3.0:1	77.5:35=2.2:1	45:17.5=2.6:1	47.5:35=1.4:1	〃
♀ 0.677* (egg-sac)	81:12=6.8:1	99:36=2.8:1	45:18=2.5:1	36:25.5=1.4:1	No. 37
♀ 0.620**	66:15=4.4:1	93:30=3.1:1	42:15=2.8:1	39:21=1.9:1	No. 38

*, ** and non-marks; First antenna of 10, 11 and 12 segments, respectively.

Table 4 *Tropocyclops prasinus* (FISCHER)

Body-Length mm.	Furca Len.: Bre. (μ)	Furcal Setae in.: ou. (μ)	Leg 4, endopod 3 Len.: Bre. (μ)	Leg 4, endopod 3, spines in.: ou. (μ)	Locality
♀ 0.738	39:18=2.2:1	57:36=1.6:1	39:15=2.6:1	63:30=2.1:1	No. 24

Table 5 *Paracyclops fimbriatus* (FISCHER)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 0.866	120:18=6.7:1	72:60=1.2:1	36:21=1.7:1	54:24=2.3:1	No. 10
♂ 0.690	80:20=4.0:1	55:52.5=1.1:1	30:17.5=1.7:1	40:25=1.6:1	No. 36
♂ 0.667	87:21=4.1:1	54:51=1.1:1	33:18=1.8:1	45:25.5=1.8:1	No. 38
♀ 0.819	114:18=6.3:1	57:54=1.1:1	33:18=1.8:1	48:27=1.8:1	No. 41

Table 6 *Cyclops vicinus* (ULJANIN)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 1.346	147:36=4.1:1	132:81=1.6:1	75:39=1.9:1	78:39=2.0:1	No. 14

Table 7 *Megacyclops viridis* (JURINE)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♂ 1.404	116:32=3.6:1	232:88=2.6:1	88:44=2.0:1	76:76=1.0:1	No. 18
♀ 1.275	99:30=3.3:1	192:75=2.6:1	57:30=1.9:1	63:51=1.2:1	No. 38
♀ 1.100	93:24=3.9:1	210:75=2.8:1	51:27=1.9:1	63:45=1.4:1	No. 42
Megacyclops viridis takebuensis n. subsp.					
♀ 0.913	102:27=3.8:1	115.2:48=2.4:1	54:30=1.8:1	96*:36=2.7:1	No. 33

* transformes into seta.

Table 8 *Acanthocyclops morimotoi* ITO

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 1.435	137.5:27.5=5.0:1	202.4:64.4=3.1:1	50:35=1.4:1	37.5*	No. 35
♂ 0.911	80:20=4.0:1	150:52.5=2.9:1	40:21.3=1.9:1	37.5:27.5=1.4:1	No. 36

* without outer spine.

Table 9 *Diacyclops disjunctus* (THALLWITZ)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 0.608	54:19.5=2.8:1	21:30=0.7:1	24:18=1.3:1	25.5:21=1.2:1	No. 1
♀ 0.573	63:18=3.5:1	18:30=0.6:1	27:21=1.3:1	24:18=1.3:1	〃
♂ 0.456	42:15=2.8:1	18:21=0.9:1	21:15=1.4:1	18:15=1.2:1	No. 2
♂ 0.468	39:12=3.3:1	18:21=0.9:1	21:15=1.4:1	18:15=1.2:1	〃
♂ 0.410	42:15=2.8:1	15:27=0.6:1	22.5:15=1.5:1	17.5:15=1.1:1	No. 3
♂ 0.421	42:15=2.8:1	18:27=0.7:1	21:15=1.4:1	21:15=1.4:1	No. 6
♂ 0.421	42:15=2.8:1	18:24=0.8:1	21:15=1.4:1	21:15=1.4:1	〃
♀ 0.842 (egg-sac)	75:21=3.6:1	27:42=0.6:1	33:21=1.6:1	42:36=1.2:1	No. 13
♂ 0.737	63:18=3.5:1	42:42=1.0:1	33:21=1.6:1	39:33=1.2:1	〃
♂ 0.644	54:16.5=3.3:1	27:27=1.0:1	24:19.5=1.3:1	30:27=1.1:1	〃
♂ 0.725	60:18=3.3:1	54:33=1.6:1	27:18=1.5:1	24:21=1.1:1	No. 31
♀ 0.807	69:19.5=3.5:1	48:30=1.6:1	36:21=1.7:1	42:33=1.3:1	No. 32
♀ 0.761	75:21=3.6:1	48:36=1.3:1	36:24=1.5:1	42:33=1.3:1	〃
♂ 0.667	57:18=3.2:1	42:30=1.4:1	30:19.5=1.5:1	33:30=1.1:1	〃
♀ 0.831	75:21=3.6:1	30:39=0.8:1	36:22.5=1.6:1	42:33=1.3:1	No. 33
♂ 0.608	57:15=3.8:1	27:33=0.8:1	30:19.5=1.5:1	33:27=1.2:1	〃
♀ 0.842	75:24=3.1:1	42:39=1.1:1	33:24=1.4:1	42:34.5=1.2:1	No. 34
♀ 0.842	69:22.5=3.1:1	33:39=0.8:1	33:21=1.6:1	42:34.5=1.2:1	〃
♀ 0.796	72:21=3.4:1	33:36=0.9:1	31.5:24=1.3:1	39:34.5=1.1:1	〃
♀ 0.772	72:24=3.0:1	39:39=1.0:1	33:24=1.4:1	45:39=1.2:1	〃
♀ 0.727	62.5:20=3.1:1	30:30=1.0:1	30:20=1.5:1	37.5:32.5=1.2:1	No. 35
♀ 0.819	65:20=3.3:1	40:35=1.1:1	32.5:20=1.6:1	37.5:32.5=1.2:1	〃
♀ 0.580	50:15=3.3:1	52.5:27.5=1.9:1	22.5:17.5=1.3:1	22.5:20=1.1:1	〃
♀ 0.616	57.5:16.3=3.6:1	65:32.5=2.0:1	25:17.5=1.4:1	25:23.8=1.1:1	No. 36
♀ 0.626	57.5:17.5=3.3:1	65:32.5=2.0:1	23.8:17.5=1.4:1	25:22.5=1.1:1	〃
♀ 0.626	55:16.3=3.4:1	60:30=2.0:1	25:17.5=1.4:1	25:25=1.0:1	〃
♀ 0.589	47.5:12.5=3.8:1	30:27.5=1.1:1	22.5:15=1.5:1	30:25=1.2:1	〃

Table 10 *Diacyclops languidoides* (LILLJEBORG)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♂ 0.737	93:18=5.2:1	18:30=0.6:1	39:21=1.9:1	21:21=1.0:1	No. 2
♀ 0.608	54:18=3.0:1	21:30=0.7:1	24:15=1.6:1	27:21=1.3:1	No. 18
♀ 0.620	60:16.5=3.6:1	33:36=0.9:1	24:21=1.1:1	24:18=1.3:1	No. 23
♀ 0.538	54:15=3.6:1	24:30=0.8:1	21:18=1.2:1	24:18=1.3:1	〃
♀ 0.644	60:15=4.0:1	33:36=0.9:1	24:18=1.3:1	24:18=1.3:1	〃
♀ 0.494	45:15=3.0:1	21:27=0.8:1	21:15=1.4:1	21:15=1.4:1	〃
♀ 0.527	48:12=4.0:1	24:27=0.9:1	27:15=1.8:1	21:18=1.2:1	No. 25
♀ 0.527	48:12=4.0:1	24:27=0.9:1	27:15=1.8:1	21:18=1.2:1	〃
♀ 0.515	48:12=4.0:1	24:30=0.8:1	21:18=1.2:1	18:15=1.2:1	〃

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
♀ 0.503	48:12=4.0:1	21:30=0.7:1	18:15=1.2:1	18:15=1.2:1	No. 25
♀ 0.527	48:15=3.2:1	24:24=1.0:1	18:15=1.2:1	21:15=1.4:1	〃
♂ 0.445	42:12=3.5:1	27:27=1.0:1	18:15=1.2:1	21:15=1.4:1	〃
♀ 0.644	57:15=3.8:1	21:27=0.8:1	21:21=1.0:1	27:21=1.3:1	No. 26
♀ 0.714	60:18=3.3:1	18:36=0.5:1	27:24=1.1:1	33:27=1.2:1	〃
♀ 0.585	48:15=3.6:1	24:24=1.0:1	21:21=1.0:1	24:18=1.3:1	〃
♂ 0.597	57:15=3.8:1	18:30=0.6:1	24:18=1.3:1	27:24=1.1:1	〃
♀ 0.667	60:15=4.0:1	18:33=0.5:1	27:18=1.5:1	27:27=1.0:1	No. 27
♀ 0.702	57:15=3.8:1	18:30=0.6:1	27:18=1.5:1	27:27=1.0:1	〃
♀ 0.702	60:18=3.3:1	21:33=0.6:1	24:21=1.1:1	27:27=1.0:1	〃
♀ 0.632	54:18=3.0:1	21:33=0.6:1	27:18=1.5:1	27:27=1.0:1	〃
♀ 0.644	57:15=3.8:1	18:30=0.6:1	24:18=1.3:1	27:24=1.1:1	〃
♀ 0.702	57:16.5=3.5:1	21:36=0.6:1	27:18=1.5:1	30:30=1.0:1	〃
♂ 0.725	63:16.5=3.8:1	21:33=0.6:1	27:18=1.5:1	30:30=1.0:1	〃
♂ 0.562	36:15=2.4:1	18:27=0.7:1	24:15=1.6:1	24:21=1.1:1	〃
♀ 0.494	51:15=3.4:1	33:30=1.1:1	21:18=1.2:1	21:15=1.4:1	No. 28
♀ 0.480	39:15=2.6:1	21:30=0.7:1	18:16.5=1.1:1	19.5:13.5=1.4:1	〃
♀ 0.608	69:15=4.6:1	15:33=0.5:1	28.5:18=1.6:1	27:24=1.1:1	〃
♀ 0.655	66:15=4.4:1	18:30=0.6:1	27:18=1.5:1	27:24=1.1:1	No. 33
♀ 0.538	54:12=4.5:1	21:27=0.8:1	24:15=1.6:1	21:15=1.4:1	〃
♂ 0.608	63:15=4.2:1	18:30=0.6:1	25.5:15=1.7:1	27:24=1.1:1	〃

Table 11 *Diacyclops languidoides japonicus* ITO

Body-Length mm.	Furca Len.: Bre. (μ)	Furcal Setae in.: ou. (μ)	Leg 4, endopod 3 Len.: Bre. (μ)	Leg 4, endopod 3, spines in.: ou. (μ)	Locality
♀ 0.749	63:21=3.0:1	69:30=2.3:1	33:21=1.6:1	24:21=1.1:1	No. 19
♀ 0.754	62.5:17.5=3.6:1	97.5:35=2.8:1	30:20=1.5:1	27.5:23.8=1.2:1	No. 35
♀ 0.718	70:17.5=4.0:1	87.5:35=2.5:1	28.8:20=1.4:1	27.5:25=1.1:1	〃
♂ 0.626	65:12.5=5.2:1	67.5:30=2.3:1	25:17.5=1.4:1	25:22.5=1.1:1	〃
♂ 0.580	60:13.8=4.3:1	80:32.5=2.5:1	25:15=1.7:1	25:22.5=1.1:1	〃
♀ 0.626	62.5:12.5=5.0:1	70:30=2.3:1	27.5:17.5=1.6:1	22.5:20=1.1:1	No. 36
♀ 0.718	77.5:15=5.2:1	85:32.5=2.6:1	27.5:20=1.4:1	28.8:25=1.2:1	〃
♀ 0.699	65:17.5=3.7:1	95:35=2.7:1	30:20=1.5:1	27.5:22.5=1.2:1	〃
♀ 0.754	75:17.5=4.3:1	92.5:35=2.6:1	30:20=1.5:1	27.5:25=1.1:1	〃
♀ 0.718	77.5:20=3.9:1	105:40=2.6:1	32.5:22.5=1.4:1	30:27.5=1.1:1	〃
♂ 0.681	67.5:15=4.5:1	70:30=2.3:1	27.5:17.5=1.6:1	23.8:22.5=1.1:1	〃
♂ 0.644	70:17.5=4.0:1	80:32.5=2.5:1	27.5:17.5=1.6:1	25:20=1.3:1	〃
♂ 0.589	55:15=3.7:1	85:30=2.8:1	25:17.5=1.4:1	22.5:20=1.1:1	〃
♂ 0.635	55:15=3.7:1	82.5:30=2.8:1	27.5:17.5=1.6:1	22.5:20=1.1:1	〃
♂ 0.635	65:15=4.3:1	80:27.5=2.9:1	27.5:17.5=1.6:1	23.8:22.5=1.1:1	〃
♀ 1.065	105:24=4.4:1	126:42=3.0:1	39:24=1.6:1	48:43.5=1.1:1	No. 42
♂ 0.878	93:19.5=4.8:1	111:45=2.5:1	42:21=2.0:1	42:36=1.2:1	〃

Table 12 *Diacyclops languidoides suoensis* n. subsp.

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 0.585	54:15=3.8:1	21:27=0.8:1	24:15=1.6:1	24:21=1.1:1	No. 46
♀ 0.714	57:18=3.1:1	30:30=1.0:1	27:21=1.3:1	36:27=1.3:1	〃

Table 13 *Diacyclops* sp.

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♂ 1.065	117:24=4.9:1	108:90=1.2:1	69:24=2.9:1	60:48=1.3:1	No. 1

Table 14 *Microcyclops (Microcyclops) varicans* (SARS)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 2 Len.: Bre.	Leg 4, endopod 2, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 1.440	63:15=4.2:1	63:39=1.6:1	63:24=2.6:1	36:24=1.5:1	No. 24

Table 15 *Mesocyclops leuckarti* (CLAUS)

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 0.878	108:30=3.6:1	240:99=2.5:1	84:30=2.8:1	78:75=1.0:1	No. 45
♀ 1.476	126:36=3.5:1	277.2:96.8=2.9:1	90:30=3.0:1	87:81=1.1:1	No. 48
♀ 1.710	126:39=3.2:1	338.8:114.4=3.0:1	96:33=2.9:1	99:99=1.0:1	〃
♀ 1.620	126:39=3.2:1	286:96.8=3.0:1	99:33=3.0:1	84:84=1.0:1	〃
♀ 1.638	126:39=3.2:1	308:127.6=2.4:1	99:39=2.5:1	93:87=1.1:1	〃
♀ 1.710	144:42=3.4:1	321.2:127.6=2.5:1	99:39=2.5:1	102:99=1.0:1	〃

Table 16 *Thermocyclops uénoi* ITO

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 3 Len.: Bre.	Leg 4, endopod 3, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 1.195	96:21=4.6:1	90:66=1.4:1	57:21=2.7:1	54:36=1.5:1	No. 49
♀ 1.192	96:21=4.6:1	90:66=1.4:1	54:21=2.6:1	51:36=1.4:1	〃
♀ 0.962	81:24=3.4:1	54:42=1.3:1	42:21=2.0:1	39:27=1.4:1	〃
♀ 0.836	99:24=4.1:1	87:63=1.4:1	54:24=2.3:1	51:33=1.5:1	〃
♀ 0.819	63:18=3.5:1	66:36=1.8:1	48:18=2.7:1	42:24=1.8:1	〃
♀ 0.751	75:21=3.6:1	57:39=1.5:1	42:21=2.0:1	39:27=1.4:1	〃
♂ 0.858	69:18=3.8:1	63:39=1.6:1	48:18=2.7:1	43:27=1.6:1	〃

Table 17 *Speocyclops yezoensis* n. sp.

Body-Length mm.	Furca Len.: Bre.	Furcal Setae in.: ou.	Leg 4, endopod 2 Len.: Bre.	Leg 4, endopod 2, spines in.: ou.	Locality
	(μ)	(μ)	(μ)	(μ)	
♀ 0.363	24:18=1.3:1	9:18=0.5:1	21:18=1.2:1	24:15=1.6:1	No. 6

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Vol. 1, No. 3, July 30, 1954.

On a Rare Adult Berycoid Fish, *Diretmus argenteus* JOHNSON, Obtained from Japan*

(*With 3 Text-figures*)

KIYOMATSU MATSUBARA

Some years ago I was given an opportunity of examining a large collection of fishes kept in the Saito Ho-Onkai Museum in Sendai through the courtesy of Prof. S. HATAI, Director of the Museum. Among them I very fortunately came across an interesting adult specimen of deep-sea berycoid fish, *Diretmus argenteus* JOHNSON measuring 211 mm in standard length (265 mm in total length), which had evidently been unrecorded from the Japanese waters**. This specimen was obtained from Japan, but the exact locality is unknown.

Since JOHNSON (1863:403, pl. 36, fig. 2) described from a young specimen measuring 3.8 inches long taken in Madeira, various authors*** have dealt with this fish taken from various parts of the world. But, unfortunately no record of the adult specimen of this fish has been made until BARNARD and von BONDE (1944:237, fig.) made the first record of a spent female specimen measuring 370 mm in standard length taken off the west coast of Capa Peninsula, South Africa. Lately, MAUL (1949:31, fig. 12) described a specimen of this species measuring 288 mm in standard length obtained near the surface about midway between Desertas and Madeira. It appears to be the second record of an adult as pointed by him. Since then nothing has been added to our knowledge of this adult fish.

The present specimen, which appears to be the third adult one throughout the world, agrees fairly well with their two adults except for some features. In the present paper, however, I fully treated this rare fish with a view to supplement the specific characters as well as to indicate some individual variations of this fish.

Description:—D. 26; A. 21; P. 18; V. I, 6; C. 6+19+5; scales about 90 counting lengthwise from upper end of gill-opening to base of caudal fin; bran-

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* Contribution from the Department of Fisheries, Kyoto University.

** After this paper went to press Dr. ABE described this species from Kesen-numa, Miyagi Prefecture.

*** CAMPBELL, 1879:298, fig. (*Discus aureus*, a synonym of the present species); GÜNTHER, 1887:45 (*Diretmus argenteus* and *Diretmus aureus*, the latter one is a synonym of the present species); VAILLANT, 1888:355 (*Gyrinomene nummularis*, a synonym of the present species); GOODE and BEAN, 1895:211, pl. 65, fig. 234; MCCULLOCH, 1909:320; ZUGMAYER, 1911:107, pl. 5, fig. 7; ROULE, 1919:52; MCCULLOCH, 1929:131, NORMAN, 1930:342; ROULE and ANGEL, 1930:78, pl. 4, fig. 100; ROULE and ANGEL, 1933: 83; PARR, 1933:6, fig. 2; FOWLER, 1936:540, fig. 255; NORMAN, 1939:54; BARNARD and von BONDE, 1944:237, fig.; SMITH, 1949:150, fig. 285; MAUL, 1949:31, fig. 12.

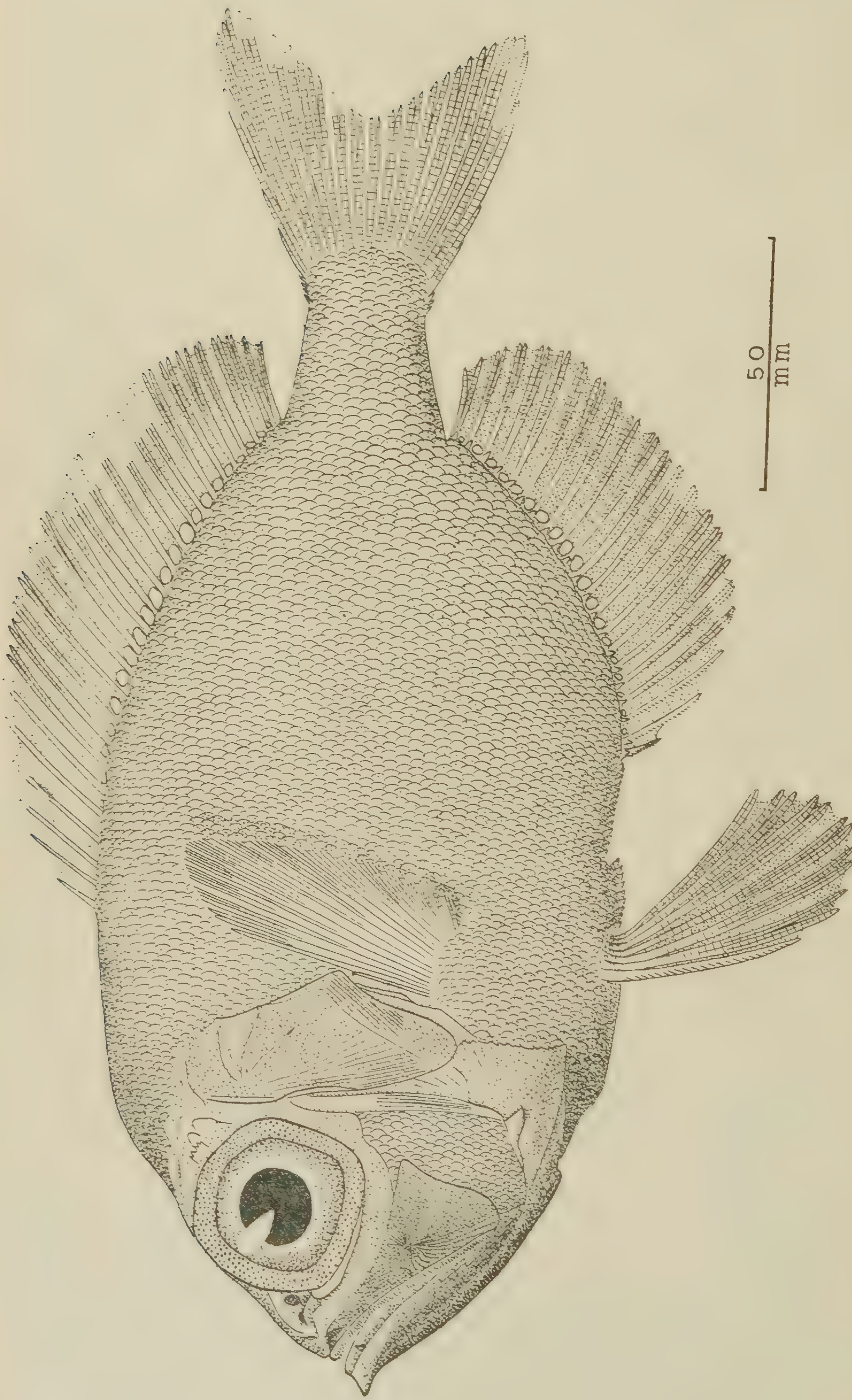


Fig. 1. *Diretmus argenteus* JOHNSON in lateral view, 211 mm. in standard length. Drawing by author.

chiostegals 8; gill-rakers on first arch 7+13.

Head 2.78 in body length; width of body 6.21; depth 2.03. Snout 5.24 in head; upper jaw 1.57; width of maxillary 3.45; orbit 2.29; bony part of interorbital space 5.85; postorbital part of head 2.31; length of caudal peduncle 3.04; depth of the same 3.42; pectoral 1.29; ventral also 1.29; ventral spine 1.93. Longest gill-raker on first arch 2.37 in orbit; longest gill-lamella 2.94.

Body is much lower than in the young specimen, the greatest depth immediately behind the head is about half the length of body and 1.37 times the length of head. Upper profile of head is rather steep and straight from tip of snout to roundly elevated nuchal region. Eye is very large and round, its upper limb impinging the upper profile of head when viewed from the lateral side; the diameter of orbit is about as long as 2.3 times the length of snout which is very short. Interorbital region is abraded, but is apparently slightly convex. A pair of the thin and rather high bony keels is running near the median line of the interorbital region, the keels converge anteriorly, meeting immediately above the anterior margin of pupil, then diverge anteriorly for the reception of the prominent upper heads of the premaxillaries between them; a pair of similar keels is bordering the lateral margins of the interorbital region. Nostrils are large, round and closed together, having no nasal tubes. Suborbital and opercular bones are mostly papery, without skin and roughened by radiately ribbed striae; each stria on preopercle and interopercle ends in a fine spine which is hardly visible without an aid of lens; interopercle is mostly hidden under broadly produced preopercle and the hind margin is widely and deeply emarginated, thus the angle of the bone forming a broad lanceolated process which is hidden under the preopercle. Opercle is armed with three weak ridges, which do not end in spines. Angle of cheek is armed with a thin, short triangular bony process.

Mouth is large, oblique, the posterior extremity of upper jaw is extending slightly beyond the hind margin of the pupil; the lower jaw is projected beyond the tip of upper jaw when mouth is closed. Premaxillary and lower jaw are armed with a moderately wide band of small villiform teeth which are curved inward; the outer teeth of the premaxillary are, however, minute and granular in shape; the band of teeth in each jaw progressively becomes narrower posteriorly. Vomer and palatines are edentulous; vomer is very prominent, knob-like and bearing a blunt longitudinal ridge along median line of the upper anterior surface of the bone. Maxillary is composed of two pieces; the posterior one, which may probably represents a supplemental bone, is much larger than the anterior one and finely sculptured by radiating ribbed striae, the width of the bone at the posterior extremity is about two-thirds the diameter of orbit; the anterior piece of the maxillary is armed with fine longitudinally ribbed striae, the lower anterior extremity of the bone terminates in a prominent process,

forming a peculiar fang-like projection inside the mouth on each side of the vomerine ridge; this peculiality is well illustrated by BARNARD and von BONDE. Lower jaw forms a prominent and rather sharp symphysial process which is directed donwward and forward; the lateral face of the lower jaw is also roughened by longitudinally ribbed striae. Tongue is short, thin and papery, the upper surface is quite smooth.

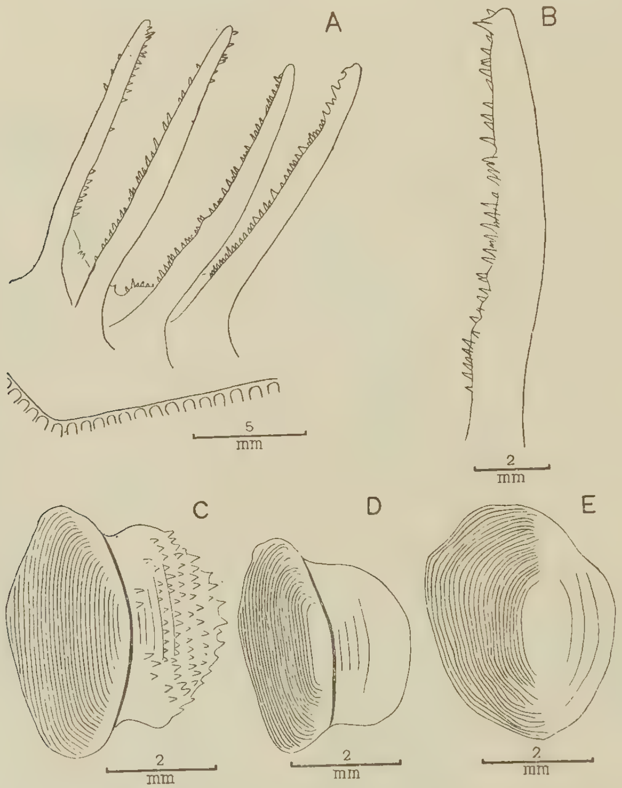


Fig. 2. Gill-rakers and scales in *Diretmus argenteus* JOHNSON. A, outer side of gill-rakers on angular part of the first gill-arch; B, lateral view of a gill-raker; C, scale on central part of the side of body; D, scale in axil of pectoral; E, scale above vent. Drawings by author.

Gill-openings are very wide, extending forward to below the anterior margin of the orbit; gill-membranes are free from the isthmus. Two anterior branchiostegals are very small and feeble, but the other ones are large and flattened. Gill-rakers are long and rigid, the longest one on first arch is about 1.25 times as long as the longest gill-lamella; the inner margin of each gill-raker is armed with two or three series of sharp spines (Fig. 2 A·B). A slit, which is slightly shorter than one-third the diameter of orbit, can be seen behind the fourth arch. Pseudobranchiae are well developed, with 28 gill-lamellae, length of the base is

half the diameter of orbit and the longest lamella is much longer than the longest gill-lamella on first arch.

Vent is nearer base of ventral than origin of anal fin (Figs. 1 and 3 E).

Lateral line is entirely absent. Rather small imbricated scales are seen on body and cheeks; they are mostly ctenoid and peculiar shape; the covered portion is elliptical in shape and finely sculptured by circuli which never extend to the

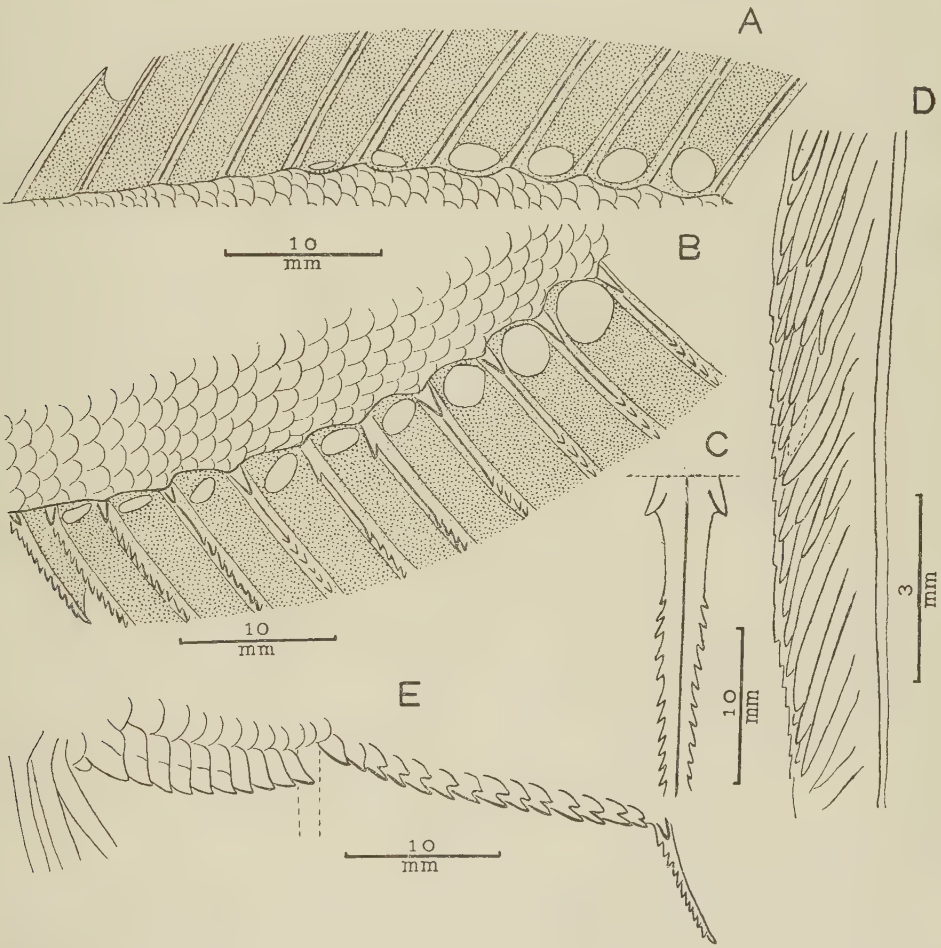


Fig. 3. Anterior parts of both dorsal (A), and anal (B) fins, anterior face of seventh anal ray (C), ventral spine (D) and abdominal scutes (E) in *Diretmus argenteus* JOHNSON. Drawings by author.

exposed portion; the exposed portion is semicircular in shape and covered with five or six transverse rows of triangular spinules; the junction between these two portions is deeply constricted and posterior margin of the covered portion is greatly thickened (Fig. 2 C); the scales in the axils of the pectorals have, however, no spinules (Fig. 2 D) and those above the vent are wanting both spinules and

thickened portion (Fig. 2 E). Cheeks are armed with 12 vertical rows of ctenoid scales; other parts of the head are naked except in the nuchal region. Fins are all naked.

Abdominal scutes are strong, pungent, forming a sharp abdominal keel; the first one is immediately behind the last ventral ray, 10 to the vent and 12 between vent and origin of the anal fin.

Dorsal rays are all flattened antero-posteriorly, the lateral keels are armed with a row of spinules, the asperities, however, become weaker posteriorly and are scarcely discernible on several posterior rays; no basal spines are found in each ray; from the seventh ray they are apparently bifurcated and segmented; interradial membranes are rather delicate, but mostly intact and so-called "windows" or "perforations" can distinctly be seen between each ray from fifth to last ray, the windows become larger toward the middle portion of the fin, the largest one is about a ninth the diameter of orbit (Figs. 1 and 3 A).

Anal fin is similar to the dorsal fin in structure; the rays are, however, all segmented, bifurcated from the fourth ray, and each with a basal spine on each side (Fig. 3 B · C); the interradial windows are seen except on the first membrane and become larger toward the middle portion of the fin (Figs. 1 and 3 B).

Pectorals are directed upward and slightly backward; the rays are all segmented and slightly roughened by small asperities; the two anteriormost rays are simple, but the other ones are evidently branched.

Ventrals are very long, just as long as the pectorals, the soft rays are also roughened by small asperities and branched; ventral spine is peculiar in structure, composed of a mass of rod-like bodies which are running downward and slightly outward and can be split one by one by using a sharply pointed pin (Fig. 3 D).

Caudal fin is evidently forked and roughened, but the asperities become stronger toward the outer rays; upper and lower vestigial rays are edged by fine serrations.

In formalin body and cheeks are greyish blue; fins and bony parts of the head are brownish black. Buccal cavity, branchial chamber and peritoneum are dark brown, but the peritoneum is more or less paler. Alimentary canal is pale.

Remarks:—BARNARD and von BONDE (1944:239) suggested that the so-called "interradial windows" found in both dorsal and anal fins are actually due to scarcity of pigment and not to the absence of membrane, but I suppose them to be due to the absence of membrane as considered by CAMPBELL (1879:298) and others inasmuch as the perforations are regular in shape and gently become larger toward the middle of the fin. It should be mentioned that the vent opens midway between ventrals and anal, with the scutes both in front and behind it as described by BARNARD and von BONDE, although they considered that this

might be due to malformation.

It is interesting to note that the present species has the ventral spine composed of a mass of rod-like bodies which are running downward and slightly outward and can be split one by one by using a sharply pointed pin. So far as my knowledge is concerned such structure in ventral spine has never been reported in other fishes.

In my specimen the number of branchiostegals, dorsal and anal rays and abdominal scutes are more or less fewer than those of BARNARD and von BONDES' specimen (branchiostegals 9, dorsal rays 28, anal rays 23 and abdominal scutes 14+12 in the latter). In addition to this fact it may be noticed that in my specimen the basal spines in dorsal rays are entirely absent.

The specimen observed by me disagrees in having fewer number of both dorsal and anal rays, larger number of caudal rays, fewer number of branchiostegals, wider body, shorter snout, longer eye and narrower interorbital space from that of MAUL's *Diretmus argenteus* (1949:31, fig. 12) which has dorsal rays 28, anal rays 22, caudal rays 4+16+4, branchiostegals 9, width of body 7.58 in body length, snout 3.55 in head, eye 2.64 and the interorbital space 4.48.

Paradiretmus circularis WHITLEY (1948:84, fig. 6) can not be the young of this species at least in having the anterior dorsal and anal rays spinous and the fins each preceded by a procumbent spine. The species, moreover, having fewer number of scales in lengthwise series than the present species (ca. 30 instead of being ca. 90). WHITLEY (1951:62) eliminated the genus *Paradiretmus* from the family Diretmidae and proposed a new family Paradiretmidae for it.

Acknowledgement:—I wish to thank Dr. S. HATAI for making a specimen of this species available for examination. I am indebted especially to Dr. G. P. WHITLEY of Australian Museum, Sydney for sending me the copies of the original description and figure of *Paradiretmus circularis*.

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Vol. 1, No. 3, July 30, 1954

Some Remarks on the Family Liparidae, with Descriptions of Three New Species and Two Interesting Ones of the Genus *Liparis**

(With 11 Text-figures & 1 Table)

KIYOMATSU MATSUBARA and TAMOTSU IWAI

Recently, while attempting to identify our large number of specimens of fishes of the family Liparidae taken around the waters of Japan, we have become interested in the relations among the genera of this family and found a number of interesting features of their own, some of which will serve for distinguishing the three genera, *Liparis*, *Crystallias* and *Careproctus*. We also came across three new species and two other interesting ones of the genus *Liparis*.

The present instalment is a part of the results of our investigations on the deep-sea fishes of Japan and its adjacent regions, but for convenience' sake some of the shallow water fishes are included in it. Expenses for investigations of this series were defrayed from 1943 to 1945 from a research fund contributed by Mr. Keizo SHIBUSAWA and since 1948 from the grant-in-aid by the Ministry of Education.

Some remarks on the family Liparidae

The number of pyloric coeca and nostrils, the presence or absence of pseudobranchiae, and the extention of the gill-slit have hitherto been particularly taken into consideration to classify the Liparidae into a number of genera (GILBERT and BURKE, 1912; BURKE, 1930). In order to understand the relations existing among the genera more satisfactorily we have examined the sensory canal system of the head, alimentary canal, pelvic girdle and the osteological features of the disk in *Liparis tessellatus* (GILBERT et BURKE), *L. frenatus* (GILBERT et BURKE), *Crystallias matsushimae* JORDAN et SNYDER, and *Careproctus rastrinus* GILBERT et BURKE.

Sensory canal system:—The sensory canal system of the head in fishes has been discussed in the works by many authors (LEKANDER, 1949:1–4; GOSLINE, 1949:2), and has frequently been used as the features for classification purposes in various groups of fishes. The taxonomic importance of this organ in the family Liparidae has already been suggested by BURKE (1930:9–10). A careful

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* Contribution from the Department of Fisheries, Faculty of Agriculture, Kyoto University.

examination of this organ, by means of the injection method using 0.2% methylene blue, has revealed some additional facts.

The three genera treated here are generally the same in their sensory canal system of the head. The canal usually opens outward regularly here and there in a short tube. The supracorbital canal (SO.C), which begins near the

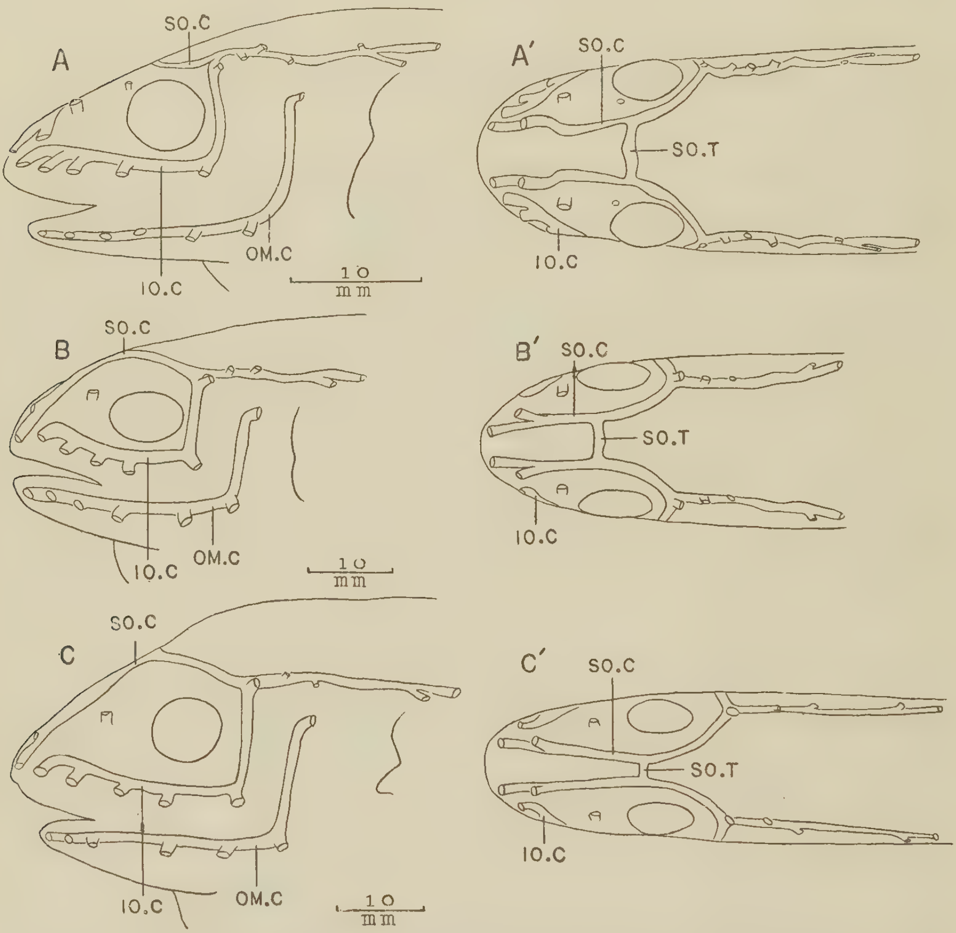


Fig. 1. Sensory canals and pores viewed from the above and side of the head in three species of the family Liparidae. A.A′, *Liparis tessellatus*; B.B′, *Careproctus rastrinus*; C.C′, *Crystallias matsushimae*. IO.C, infraorbital canal; OM.C, operculo-mandibular canal; SO.C, supraorbital canal; SO.T, supraorbital tube-commissure. Drawings by junior author.

tip of the snout, runs backward and upward on either side of the tip of the head in a straight line as far above the eye, where it turns lateral until it clearly forms an angle behind the eye, and then it extends in a straight line on the dorsolateral side of the head until it terminates at a short distance behind the upper angle of the gill-slit. There is no posterior extension of this canal

which connects with the lateral line system of the body. It is connected with the fellow of the opposite side by a supraorbital tube-commissure (SO.T), and incorporates with the upper extremity of the infraorbital canal (IO.C) at the upper posterior part of the eye. The supraorbital tube-commissure is much longer in *Liparis* (Fig. 1A) and *Careproctus* (Eig. 1B), being about as long as half the width of the muscular part of the interorbital space, while in *Crystallias* it is about one-third as long (Fig. 1C). From the supraorbital canal 2 pores open outward on the snout and immediately behind the upper end of the gill-slit respectively. In addition to these pores there are 2 more pores in *Crystallias* and *Careproctus*, 3 or 4 in *Liparis*, behind the eye. So far as the lastmentioned group of pores is concerned, they have never failed to be overlooked by such authors as GARMAN and BURKE (GARMAN, 1892: pl. 3, Fig. 1; BURKE, 1930: 9) probably due, in part at least, to the fact that they are much smaller than those of the other series.

The infraorbital canal (IO.C) which begins immediately behind the anterior-most pore of the supraorbital canal, runs backward in a straight line as far below and behind the eye, and then turns upward at a right angle and ascends to meet the supraorbital canal. The pores are invariably 6 in number, of which 2 are found on the lateral side of the snout and below the eye respectively, and 1 pore, at the angle of the canal and at the junction of the supra-orbital canal respectively.

The preopercular and mandibular canals join each other, forming the so-called "operculo-mandibular canal" (OM.C). It begins near the tip of the lower jaw, runs in parallel with the infraorbital canal, and ends between the eye and the upper end of the gill-slit. The canal is neither joined at the symphysis of the lower jaw with the fellow of the opposite side, nor connected at the upper extremity with the supraorbital canal. There are 3 pores on the mandible and 4 pores on the preopercular region.

So far as the infraorbital and operculo-mandibular canals are concerned, no significant differences were found to exist among these three genera. The supratemporal canal running transversely across the top of the occiput is entirely absent in these genera.

Disk and pelvic girdle:—The fishes of the family Liparidae and their related ones are primary distinguished from the other members of the mail-cheeked fishes in having the ventral fin modified into a sucking disk, although it has become lost in some of the the deep-water genera. The disk with a spine and five soft rays, which are generally much longer in *Crystallias* (Fig. 2A) than in either *Liparis* or *Careproctus* (Fig 2B-C). The second or the third soft ray is the longest, about two-thirds as long as the pelvic girdle in *Crystallias*, but is equal to or even shorter than one-third of the length of the girdle in the others.

Each half of the pelvic girdle is well separated. In *Careproctus* the girdle in front of the disk is very slender and much longer than the remaining part of it, but in the other genera it is broad and about as long as or even shorter. The subpelvic process (MATSUBARA, 1943: 120), which extends forward and downward in front of the disk, is broad in *Careproctus*, but is very slender in the others.

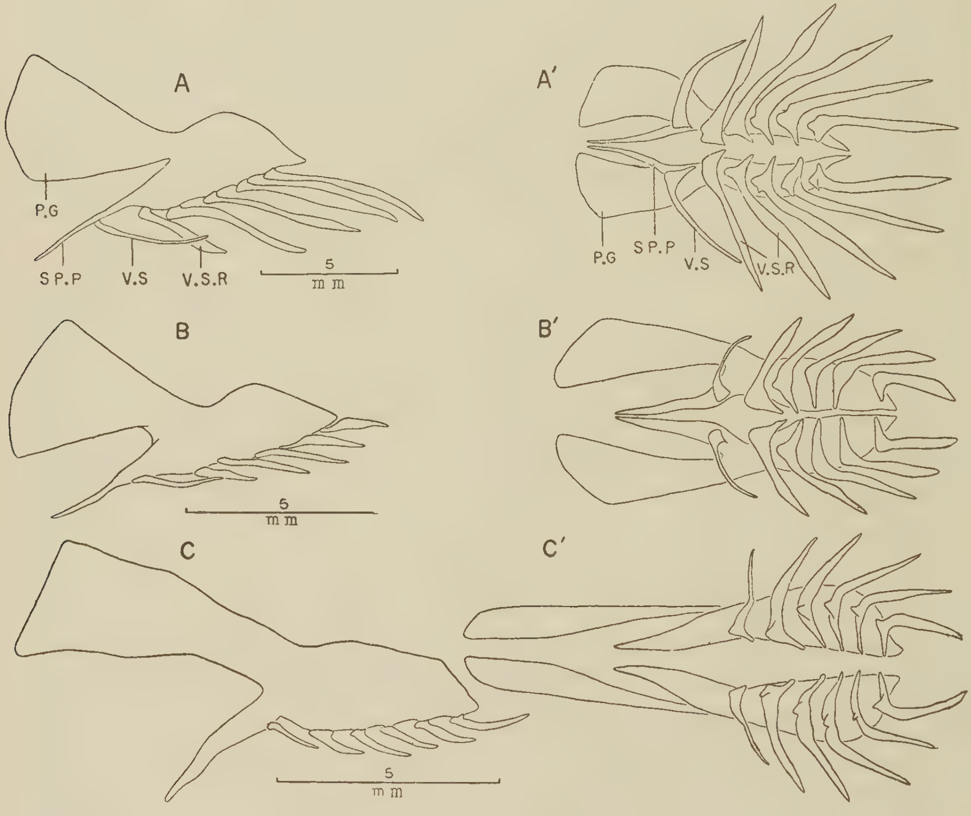


Fig. 2. Lower and lateral aspects of pelvic girdle and pelvic fin in three species of the family Liparidae. A.A′ *Crystallias matsushimae*; B.B′, *Liparis tessellatus*; C.C′, *Careproctus rastrinus*. P.G, pelvic girdle; SP.P, subpelvic process; V.S, ventral spine; V.S.R, ventral soft ray. Drawings by junior author.

Alimentary canal:—The alimentary canal of this group closely resembles that of the scorpaenoid fishes (MATSUBARA, 1943: 147–158, figs. 59–64), but the stomach is greatly dilated. The small intestine first descends near the posterior extremity of the coelomic cavity, then bends forward and ascends near the basal part of the pyloric coeca, where it again bends backward. Thus, the small intestine is composed of three compartments, but considerable differences are exhibited in the shape of the last section in the three genera. It runs straight backward and opens immediately ahead of the beginning of the anal fin in

Liparis (Fig. 3A), whereas it bends again forward and ascends near the basal part of the pyloric coeca and opens immediately behind the disk in *Careproctus* (Fig. 3C). *Crystallias* is just intermediate in this feature between these two genera (Fig. 3B).

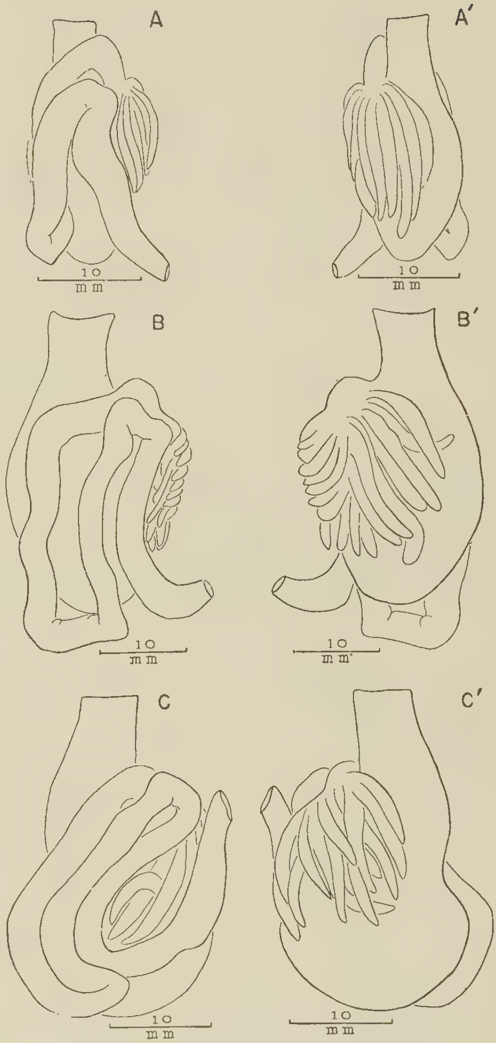


Fig. 3. Right (A-C) and left (A′-C′) aspects of alimentary canal in three forms of the family Liparidae. A.A′ *Liparis tessellatus*; B.B′, *Crystallias matsushimae*; C.C′, *Careproctus rastrinus*. Drawings by junior author.

Description of species *Liparis miostomus*, new species

Holotype:—No. 13291 (the numbers refer to MATSUBARA's Fish Collection, in which usually each specimen bears a separate number), mature male, 76.8 mm. in standard length (90.8 mm. in total length), shallow water off Kushiro, Hokkaido by beach seine, March, 1938.

Paratypes:—8 mature specimens (3 males and 5 females), Nos. 13286–13290, 13292–13293 and 13304, 64.0–84.0 mm, (75.5–100.0 mm.), taken at the same time with holotype.

Description:—The present species is a dwarf form inhabiting in the shallow water, and more closely related to *Liparis curilensis* (GILBERT et BURKE) than any other species of the genus *Liparis*.

D. 33 (33 in male paratypes; 32–34 in female paratypes); A. 25 (25–26 in both sexes); P. 27 (28; 26–28); pyloric coeca (31–38; 34–39); vertebrae (36–38; 35–38); gill-rakers on lower limb of outer arch (5; 4–5), none on upper limb.

Measurements in hundredths of standard length, exclusive of caudal fin: Length of head 24.9 (24.2–26.4; 23.9-25.7); depth opposite front of disk 14.3 (14.7–16.8; 13.2–16.7); same opposite gill-slit 19.5 (18.8–20.2; 18.6–21.7); greatest depth 23.4 (20.3–23.2; 20.5–24.0); greatest width of head 20.4 (19.7-22.7; 20.0–22.9);

same of body 18.4 (18.2–21.4; 21.2–22.1); snout 9.8 (10.0–10.1; 9.7–10.5); eye 3.5 (3.1–3.7; 2.9–3.6); interorbital space 7.8 (7.8–8.8; 7.4–9.0); width at angles of mouth 9.4 (9.4–10.7; 9.7–11.1); upper jaw 7.0 (7.3–7.8; 6.8–8.6); gill-slit 5.9 (5.5–6.2; 5.2–5.9); diameter of disk 15.6 (15.5–17.2; 14.5–16.9); distance from tip of snout to disk 13.0 (11.9–13.8; 12.3–13.2); from disk to vent 7.6 (6.3–8.7; 6.2–8.3); from vent to front of anal fin 11.7 (10.1–11.9; 9.6–11.8); from tip of snout to front of dorsal fin 30.6 (30.0–31.3; 30.2–32.4); longest pectoral ray of upper lobe 15.4 (15.5–16.3; 14.4–16.7); same of lower lobe 12.8 (10.7–12.5; 10.9–13.2); shortest pectoral ray in notch 8.9 (7.8–9.5; 7.9–8.6); caudal 18.4 (17.9–20.1; 18.3–19.5).

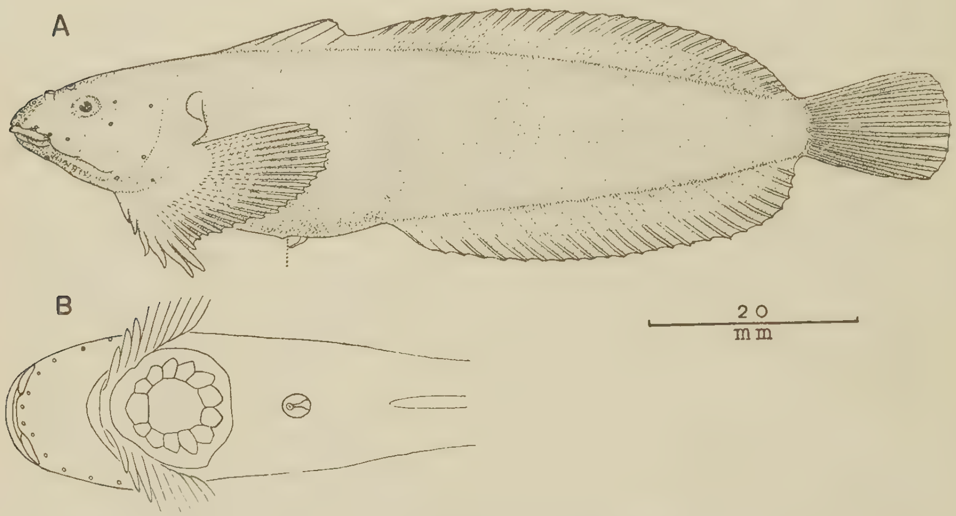


Fig. 4. ***Liparis miostomus*, new species. After holotype. A, lateral aspect of body; B, ventral aspect of anterior part of body. Drawn by senior author.**

Head and trunk heavy and little compressed, deepest at vent; tail compressed and more or less slender. Head obtuse, depressed and broader than deep, the upper profile gently arched from tip of snout to above the anterior nostril, then nearly straight to insertion of dorsal fin; cheeks well swollen. Snout depressed, always much longer than twice the diameter of eye, nearly truncated at the tip when view from the upper side and never projecting beyond tips of premaxillaries. Interorbital space broad, slightly rounded, the narrowest part always much wider than twice the diameter of eye. Anterior nostril opening at the tip of prominent tube; posterior nostril with a slightly raised rim. Eye very large, always more or less shorter than a seventh the length of head. Mouth rather broad, but with little lateral cleft; angle of mouth reaching a vertical through base of anterior nostril; lower jaw included under closed mouth. Upper lip rather thickened, extends around angles of mouth and to lateral two-thirds of each ramus of lower jaw. Teeth stout, not strongly but distictly

trilobed (Fig. 5A), in a broad band, arranged in 9 (8–9; 9–10) oblique rows in each half of upper jaw and 10 (9; 9–10) in each half of lower jaw. Tongue heavy, round and free in front. Gill-slit extending down nearly to base of uppermost pectoral ray.

Thumb-tack prickles entirely absent in both male and female.

Dorsal fin rather low, the first four rays set off by a notch; last dorsal and anal rays shortened and connected to base of caudal by membrane. Caudal slightly rounded. Pectoral broad, shallowly notched, the upper lobe reaches to or extending slightly beyond vent; the lower lobe thickened, falling short of front of vent by a distance about equal to length of snout. Disk nearly round, much longer than the distance from vent to front of anal fin and always much longer than half the length of head. Vent separated from disk by a distance about equal to half the diameter of disk; distance from vent to front of anal fin shorter than twice the distance from disk to vent.

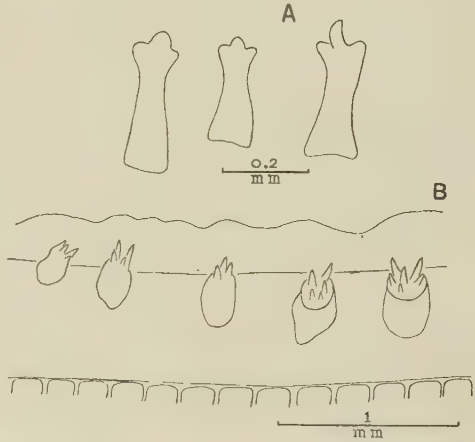


Fig. 5. Teeth on upper jaw (A) and gill-rakers on lower limb of outer arch (B) in *Liparis moistomus*. After paratype, No. 13286. Drawn by senior author.

Gill-rakers tubercular in shape, their tips armed with 3 to 6 sharp spinules Fig. 5B).

Color in formalin dark brown above and sides, more or less paler below; fins colored the same as body, without any markings, but the margins usually paler.

Remarks:—The present species resembles *Liparis curilensis* (Gilbert et Burke) at least in having short pectorals, notched dorsal, dorsal and anal fins not extending beyond base of caudal fin, and gill-slit extending merely to opposite base of uppermost pectoral ray, but the physiognomy, with included lower jaw (jaws about equal in the latter), narrower mouth (the width 9.4 to 11.1 in hundredths of standard length instead of being 15.0 in the latter), shorter upper jaw (the cleft of mouth ends below the base of anterior nostril, not extending as far below the anterior half of the eye), together with much fewer pyloric coeca (31 to 39, while 70 in the latter) and longer disk (much longer than the length from vent to front of anal fin or than half the length of head instead of about equaling the distance from vent to front of anal or slightly longer than half the length of head), makes it easy for us to tell this species from *Liparis curilensis*.

Liparis frenatus (GILBERT et BURKE)

Cyclogaster frenatus GILBERT et BURKE, 1912: 356, pl. 42, fig. 1, off the northwest coast of Hondo (original description), —JORDAN et THOMPSON, 1914: 281, Misaki (notes).

Liparis frenatus BURKE, 1930: 70 (distribution, relationships and remarks; after holotype). —SOLDATOV et LINDBERG, 1930: 350 (after original description). —TARANETZ, 1937: 130·132 (key and notes).

Material described:—2 specimens, Nos. 13295 (♂) and 13308 (♀) (MATSUBARA's Fish Collection), 71.5 and 68.7 mm, in standard length (83.0 and 80.0 mm. in total length), shallow water off Kushiro, Hokkaido by beach seine, March, 1938.

Description:—The holotype is known from deep-water at a depth of 207 fathoms, but there is no published reference to the occurrence of this species in the shallow water. Our specimens, which came from shallow water, disagree from the holotype in some features; the following description may serve for comparison of our specimens with the holotype.

D. 37 (36 in female specimen); A. 29 (28); P. 33 (34); pyloric coeca 22 (23); gill-rakers on lower limb of outer arch 6 (5), none on upper limb.

Measurements in hundredths of total length, exclusive of caudal fin: Length of head 26.3 (24.5); depth opposite front of disk 13.7 (13.1); same opposite gill-slit 17.5 (17.2); greatest depth 18.9 (18.6); greatest width of head 17.3 (21.4); same of body 16.5 (20.7); snout 8.4 (8.4); eye 6.2 (5.5); interocular space 8.4 (9.9); width at angles of mouth 12.6 (13.4); upper jaw 6.8 (8.4); gill-slit 8.1 (8.4); diameter of disk 11.2 (11.6); distance from tip of snout to disk 15.8 (13.5); from disk to vent 10.5 (10.9); from vent to front of anal fin 10.5 (15.3); from tip of snout to front of dorsal fin 30.5 (32.0); longest pectoral ray of upper lobe 19.3 (18.9); same of lower lobe 16.1 (16.0); shortest pectoral ray in notch 11.2 (11.2); caudal 16.1 (17.2).

Male markedly differs from female in general form of body, thus: In male head and body compressed, narrower than deep; head rather pointed and the sides nearly vertical as in holotype. In female, however, head and trunk depressed, wider than deep; head blunt and the sides more or less swollen.

Snout depressed, about equal to 1.4 (1.5) times the diameter of eye, not projecting beyond tips of premaxillaries. Interorbital space flattish, about equal to or wider than length of snout, and 1.4 (1.5) times the diameter of eye. Anterior nostril in a prominent tube, posterior one with a raised rim. Eye very large, about 4.3 (4.4) times into length of head. Mouth broader in female than in male. Jaws equal in length, upper jaw reaches to below front of eye; upper lip thin, extends around angles of mouth and to lateral two-thirds of each ramus of lower jaw. Teeth stout, distinctly trilobed (Fig. 6A), in a broad band, arranged in about 12 (11) oblique rows in half of upper jaw and 13 (12) in half of

lower. Tongue thick, round and free in front. Gill-slit extending down in front of 7 (10) pectoral rays.

In male thumb-tack prickles are scattered here and there on top of head and sides of body, the spines small and pointed (Fig. 6B·C·D); female is entirely smooth.

Caudal truncated; dorsal fin unnotched, joined to base of caudal; anal connected with basal one-fifth of caudal; the last ray of both dorsal and anal more or less shortened. Pectoral notched, the tip of upper lobe nearly extending in front of anal origin in male, but ends above vent in female; the lower lobe nearly reaching vent in male, but ends far before vent in female. Disk slightly longer than wide, about as long as or slightly shorter than half the length of head. Vent separated from disk by a distance about equal to diameter of the latter; distance from vent to front of anal fin equal to the distance between disk and vent in male, but the latter much longer than the former in female.

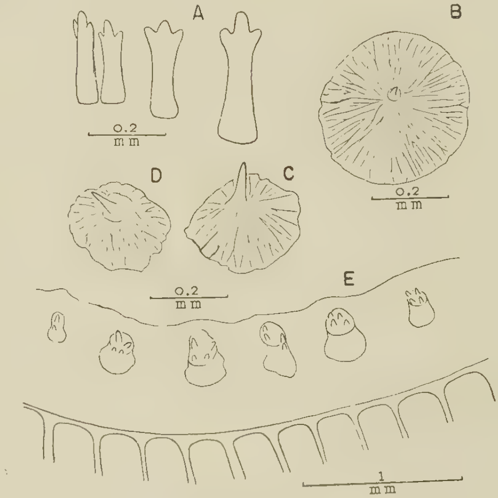


Fig. 6. Teeth on upper jaw (A), thumb-tack prickles (B.C.D) and gill-rakers on lower limb of outer arch (E) in *Liparis frenatus*. After a male specimen, No. 13295. Drawn by senior author.

Gill-rakers very small, tubercular in shape and their distal parts armed with 2 to 4 spinules.

Male markedly differs from female in coloration. In male head and body dark brown, more or less paler below, without any patterns; pectoral, dorsal and anal fins blackish brown; caudal dark brown, but the distal part more or less pale. In female head, body and fins uniformly light brown, without any peculiar patterns.

Remarks:—Our specimens thus far examined disagree from holotype of this species in the following points: 1) body slender, the greatest depth about 19 in hundredths of standard length instead of being 25 in the latter; 2) distance from disk to vent longer, about 11 in hundredths of standard length instead of being 7 in the latter; 3) teeth arranged in about 11 or 12 oblique rows in half of upper jaw and 12 or 13 in half of lower instead of being 8 rows in half of each jaw in holotype.

Thus, the present specimens differ in description somewhat from the original specimen, which was taken off the northwest coast of Hondo, but these

differences can only be expected of individual variations, since our specimens agree altogether with the holotype in other important features.

Liparis bikunin,* new species

Holotype:—No. 13318 (MATSUBARA's Fish Collection), mature female, 58.5 mm. in standard length (67.2 mm. in total length), shallow water off Kushiro, Hokkaido by beach seine, March, 1938.

Paratypes:—14 mature specimens (5 males and 9 females), Nos. 13305–13307, 13309–13317 and 13319–13320, 51.5–71.5 mm. (61.2–82.0 mm.), taken at the same time with holotype.

Description:—The present dwarf species is a shallow water form and closely resembling *Liparis frenatus* (GILBERT et BURKE) in general physiognomy.

D. 33 (32–34 in both sexes); A. 28 (26–28 in male paratypes; 25–27 in female paratypes); P. 34 (30–33 in each sex); pyloric coeca (18–21; 17–22); vertebrae (36–39; 36–38); gill-rakers on lower limb of first arch (5–7; 5–8), none on upper limb.

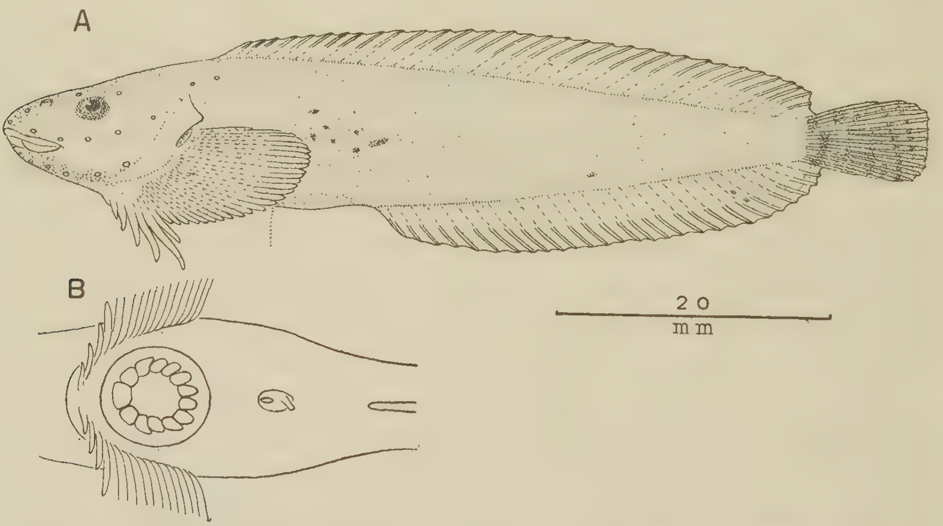


Fig. 7. *Liparis bikunin*, new species. After holotype. A, lateral aspect of body; B, ventral aspect of anterior part of body. Drawn by senior author.

Measurements in hundredths of standard length: Length of head 26.5 (24.1–26.8; 24.8–26.9); depth opposite front of disk 15.4 (13.9–16.7; 13.6–17.5); same opposite gill-slit 18.3 (17.7–20.6; 16.2–21.7); greatest depth 20.5 (20.1–24.1; 19.3–23.4); greatest width of head 19.7 (19.5–21.8; 18.5–22.0); same of body 20.5 (18.5–21.0; 18.1–22.2); snout 9.4 (8.5–9.9; 8.9–10.3); eye 4.7 (3.6–4.5; 3.6–4.9); interorbital space 7.9 (7.2–8.1; 7.3–9.1); width at angles of mouth 10.2 (9.7–10.7;

* Vulgar Japanese name for this and allied fishes, from a Sanskrit "Bhiksuni", meaning a nun.

9.9–11.4); upper jaw 8.9 (7.7–9.7; 7.9–9.4); gill-slit 6.7 (6.3–6.8; 6.0–7.1); diameter of disk 14.5 (14.5–16.8; 14.2–16.2); distance from tip of snout to disk 14.5 (12.8–14.3; 12.6–14.9; from disk to vent 7.2 (6.1–6.7; 5.5–7.4); from vent to front of anal fin 13.7 (11.2–12.6; 11.9–13.7); from tip of snout to front of dorsal fin 31.1 (29.2–32.7; 30.3–32.0); longest pectoral ray of upper lobe 15.4 (14.2–16.5; 14.5–16.5); same of lower lobe 13.7 (10.0–13.2; 10.8–13.7); shortest pectoral ray in notch 6.8 (6.7–8.5; 6.4–8.5); caudal 16.2 (15.7–17.1; 16.2–17.4).

Body slender, but head and trunk rather heavy, little compressed and deepest at shoulders; tail well compressed. Head obtuse, broad, depressed and usually more or less broader than high; the upper profile slightly convex from tip of snout to base of anterior nostril, then nearly straight to insertion of dorsal fin or slightly concave above eye. Cheek swollen. Snout well depressed, much wider than deep, about equal to or slightly longer than twice the diameter of eye, the tip nearly truncated and projecting slightly beyond tips of premaxillaries. Interorbital space broad, slightly rounded, the width about equal to or slightly narrower than twice the diameter of eye. Anterior nasal tube prominent, but never reaches to posterior nostril when the tube depressed posteriorly; posterior nostril, with slightly raised rim, minute and can not be seen without an aid of lens. Eye very small, 5.7 to 7.0 times into head length and never entering the upper profile of head. Mouth rather broad, with short lateral cleft, the upper jaw ends below base of anterior nasal tube or extends below half the way between anterior nostril and front margin of eye. Jaws nearly equal or lower jaw slightly shorter than the upper, but never included under closed mouth. Teeth in jaws stout, short and their distal parts deeply trilobed (Fig. 8A), arranged in 10 (9–10 in male paratypes; 10–12 in female paratypes) oblique rows in half of upper jaw and 10 (9–11; 10–11) in half of the lower. Tongue broad, thick and free at the tip. Gill-slit rather short, extending down in front of about upper seven pectoral rays.

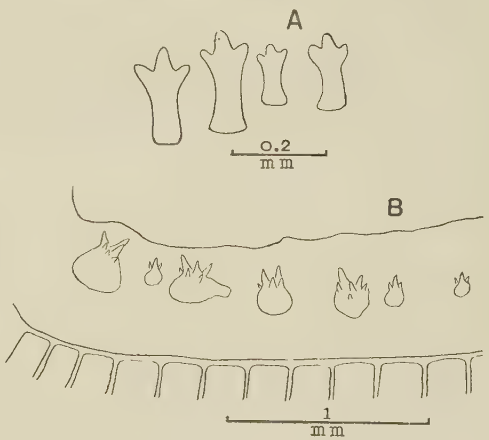


Fig. 8. Teeth on upper jaw (A) and gill-rakers on lower limb of outer arch (B) in *Liparis bikunin*. After paratype, No. 13314. Drawn by senior author.

Thumb-tack prickles entirely absent in both male and female.

Dorsal fin low anteriorly, unnotched, the last ray shortened and joined to base of caudal fin; anal narrowly joined with basal one-fifth of caudal. Caudal

truncated. Pectoral notched, the upper lobe extending slightly beyond vent; the lower lobe much shorter than the upper, the tip far apart from vent when the fin is laid back. Disk large, nearly round, about as long as or slightly longer than the distance from tip of snout to disk and slightly longer than half length of head. Distance from disk to vent about equal to or shorter than half the diameter of disk; vent separated from origin of anal fin by a distance equal to length slightly shorter than diameter of disk.

Gill-rakers small, tubercular in shape, their distal parts armed with 3 to 6 sharp spinules (Fig. 8B).

Color in formalin uniformly light brown with grayish tint, but frequently irregularly scattered with several small reddish brown blotches on sides of body; fins colored the same as body, but caudal usually marked with about five irregular dark cross bars.

Remarks:—The present species closely resembles *Liparis frenatus* (GILBERT et BURKE), but may be distinguished from it by the characteristics analysed in the following table.

Table 1 Comparison of *Liparis bikunin* with *L. frenatus* (in holotype).

Items \ Species	*L. frenatus*	*L. bikunin*
Dorsal rays	37	32–34
Anal rays	34	25–28
Cheeks	Not swollen.	Swollen.
Dist. from snout tip to disk	Much longer than diameter of disk.	About as long as or shorter than diameter of disk.
Extention of anterior nasal tube (when laid back)	Nearly reaches to posterior nostril.	Far apart from posterior nostril.
In hundredths of standard length:		
Diameter of eye	5.5	3.6– 4.7
Length of gill-slit	8.0	6.0– 7.1
Diameter of disk	10.0	14.2–16.8
Dist. from vent to front of anal fin	15.0	11.2–13.7
Longest pectoral ray of lower lobe	17.0	10.0–13.7
Shortest pectoral ray in notch	10.0	6.4– 8.5

This species bears some resemblance to *Liparis chefuensis* WU et WANG (1933: 81, figs. 2–4) and *L. Choanus* WU et WANG (1933: 83, figs. 5–6), but differs from the former in having fewer dorsal, anal and pectoral rays (dorsal 36 to 38, anal 29 to 31 and pectoral 34 to 36 in *L. chefuensis*), larger eye (eye 7.7 to 9.0 times into head in *L. chefuensis*), larger number of pyloric coeca (12 to 15 in *L. chefuensis*) and larger sucking disk (the diameter 2.0 to 2.3 times

into head in *L. chefuensis*), together with position of vent (vent opens in midway between disk and anal fin in *L. chefuensis*) and in lacking prickles. Differs from *L. Choanus* at least in having fewer anal and pectoral rays (anal 29 to 30 and pectoral 35 to 37 in the latter), larger number of pyloric coeca (14 or 15 in the latter) and much larger disk (the diameter 2.7 to 2.8 times into head in the latter).

Rather closely related to *Liparis tartaricus* SOLDATOV (in SOLDATOV and LINDBERG, 1930: 361, pl. 16, upper figure), but differs from it in having fewer dorsal rays (32 to 34 instead of being 38 in the latter), larger number of pectoral rays (30 to 34 instead of being 28 in the latter), longer gill-slit (the slit extending down in front of about upper seven pectoral rays instead of being two or three rays in the latter) and the vent much nearer the disk than anal fin (vent nearer anal fin than disk in the latter).

Liparis multiradiatus, new species

Holotype:—No. 13303 (MATSUBARA's Fish Collection), adult male, 60.5 mm. in standard length (73.0 mm. in total length), shallow water off Kushiro, Hokkaido by beach seine, March, 1938.

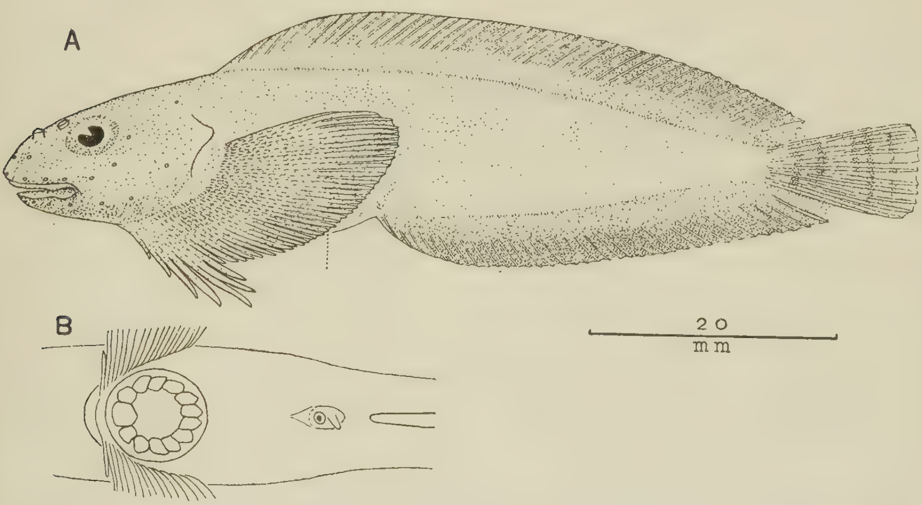


Fig. 9. *Liparis multiradiatus*, new species. After holotype. A, lateral aspect of body; B, ventral aspect of anterior part of body. Drawn by senior author.

Description:—*Liparis multiradiatus* is a dwarf species, and the physiognomy resembles tide-pool forms. D. 45; A. 37; P. 43; Br. 7; pyloric coeca 32; gill-rakers on lower limb of first arch 8, none on upper. Measurements in hundredths of total length, exclusive of caudal fin: Length of head 28.1; depth opposite front of disk 15.1; same opposite gill-slit 21.5; greatest depth 21.8; greatest width of head 20.8; same of body 16.5; snout 9.1; eye 7.0; interocular width 9.6; width at angles of mouth 16.5; upper jaw 9.1; gill-slit 9.8; diameter of disk 13.6; distance from tip of snout to disk 16.0; from disk to vent 14.9;

from vent to front of anal fin 6.4; from tip of snout to front of dorsal 32.2; longest ray of upper lobe of pectoral 22.8; same of lower lobe 17.9; shortest pectoral ray in notch 11.9; caudal 19.0.

Head and trunk heavy, little compressed and deepest at shoulders; tail compressed. Head obtuse, broad and moderately depressed, about as broad as deep, and the upper profile gently arched and occiput never especially elevated; cheeks swollen. Snout depressed, about 1.3 times as long as diameter of eye, and not projecting beyond tips of premaxillaries. Interorbital space broad, slightly rounded, and the narrowest part about 1.4 times as broad as diameter of eye. Anterior nostril in a prominent tube; posterior nostril with a raised tim. Eye very large, about equal to a fourth the length of head. Mouth very broad; lower jaw included under closed mouth; maxillary reaching a vertical from anterior end of pupil. Upper lip rather thin, extends around angles of mouth and to lateral two-thirds of each ramus of lower jaw. Teeth stout, strongly trilobed (Fig. 10A), in a broad band, arranged in about 19 oblique rows in half of upper jaw and 15 in half of the lower. Tongue thick, round and free in front. Gill-slit moderately broad, extending down in front of about upper 13 pectoral rays. Thumb-tack prickles entirely absent. Caudal truncated; dorsal fin unnotched, the last ray joined to basal one-third of caudal; the last ray of both dorsal and anal not shortened; pectoral broad, notched; the upper lobe reaches to base of second anal ray; the lower lobe not especially thickened, the longest ray extending nearly half the way between disk and vent. Disk nearly round, about half as long as the length of head. Vent separated from disk by a distance equal to length slightly longer than diameter of disk; distance from vent to origin of anal fin slightly shorter than half the distance between disk and vent.

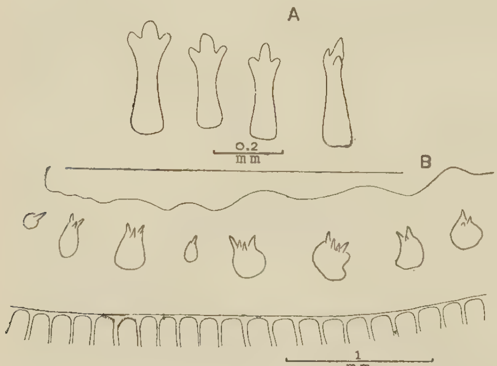


Fig. 10. Teeth on upper jaw (A) and gill-rakers on lower limb of outer arch (B) in *Liparis multiradiatus*. After holotype. Drawn by senior author.

In formalin head and body uniformly light brown, without any patterns; dorsal and anal blackish brown, become darker posteriorly; caudal light brown, furnished with five dusky cross bars; pectoral pale.

Remarks:—The present species is a dwarf form found in the shallow waters. Though apparently closely related to *Liparis ochotenis* SCHMIDT (SCHMIDT, 1904: 163, fig. 11; GILBERT et BURKE, 1912: 359, pl. 42, fig. 3; BURKE, 1930: 80, fig. 11), it differs from the latter in having larger eyes (the diameter about 4.0

times into head length instead of being about 6.0 in the latter), larger disk (the diameter about 2.0 times into head length instead of being 2.5 to 2.6 in the latter), included lower jaw (jaws about equal in the latter), and dorsal fin joined to basal one-third of caudal fin (joined to near the middle of caudal fin in the latter). Though closely related to *Liparis dubius* SOLDATOV (in SOLDATOV and LINDBERG, 1930: 366, fig.58), it appears to be recognized from the latter at least in having a much larger disk (the diameter 13.6 in hundredth of standard length, while it is 8.0 to 9.6 in the latter) and in lacking white roundish spots on the body.

Liparis tessellatus (GILBERT et BURKE)

Cyclogaster tessellatus GILBERT et BURKE, 1912: 355, fig. 2 and pl. 41, fig. 3, west of Erimo Saki, off southeast coast of Hokkaido; off coast of Korea (original description).—YANAI, 1950: 21, off Shimane Prefecture (listed).

Cyclogaster tessellata TANAKA, 1931: 46 (listed).

Liparis tessellatus BURKE, 1930: 89, fig. 18 (distribution, relationships, synopsis and remarks; after types).—SOLDATOV et LINDBERG, 1930: 347 (after original description).—TARANETZ, 1937: 131–132 (key and notes).—KATAYAMA, 1940: 20, Toyama Bay (listed). HIKITA (Toyohiko), 1951: 310 (Volcano Bay, Hokkaido).—HIKITA (Toyoji), 1951: 37 (Muroran, Hokkaido).

Material examined:—8 specimens, Nos. 9072–9077, 9081–9082 (MTSUBARA's Fish Collection), 105.5–154.0 mm. in standard length (118.5–177.0 mm. in total length), off Tsuiyama, Hyogo Prefecture, May 12, 1943.—2 specimens, Nos. 12744 and 12747, 116.0–122.0 mm. (129.0–135.8 mm.), off Uozu, Toyama Prefecture, May 16, 1950.—1 specimen No. 13267, 123.0 mm. (137.5 mm.), off Maizuru, Kyoto Prefecture, April 25, 1950.—8 specimens, Nos. 13275–13282, 130.5–160.0 mm. (148.1–183.5 mm.), off Tsuiyama, Hyogo Prefecture, April 4, 1949.—52 specimens, Nos. 13296–13302, 13321, 13323–13327, 13329–13367, 60.0–108.0 mm. (68.5–125.5 mm.), off Kushiro, Hokkaido, March, 1938.

Description:—Described by GILBERT and BURKE from 4 specimens taken off the southeast coast of Hokkaido and off the coast of Korea, several records of this species have since beeh made. In the genus *Liparis*, however, this fish is by far the most abundant species in places along the west coast of Japan, and sometimes caught in considerable quantities by means of deep-sea trawlers at a depth of about 100 meters. The present 71 specimens have given an excellent opportunity to set forth some of the individual variations of this fish.

D. 46–49; A. 35–38; P. 34–38; pyloric coeca 28–32; vertebrae 48–51; gill-rakers on lower lim of outer arch 7–9, none on upper limb.

Measurements in hundredths of standard length: Length of head 21.3–25.4; depth opposite front of disk 11.6–18.4; same opposite gill-slit 13.1–20.7; greatest depth 15.3–23.9; greatest width of head 10.9–16.6; same of body 11.2–17.5; snout 7.6–10.1; eye 4.1–8.0; interocular width 6.4–10.5; width of angles of mouth 8.1–12.6; length of upper jaw 6.7–10.1; length of gill-slit 7.4–11.4; diameter of disk 5.6–9.9; distance from tip of snout to disk 10.7–16.8; from disk to vent 11.8–

16.7; from vent to origin of anal fin 5.5–9.0; from tip of snout to origin of dorsal fin 24.5–28.9; longest pectoral ray in upper lobe 19.0–26.6; same in lower lobe 10.5–18.2; shortest pectoral ray in notch 5.2–10.4; caudal fin 11.4–16.9.

Teeth rather stout, strongly trilobed (Fig. 11A), in broad bands (Fig. 11B), arranged in 20 to 22 oblique rows in half of upper jaw and about 15 in half of the lower. In mature male head and body armed with very deciduous thumb-tack

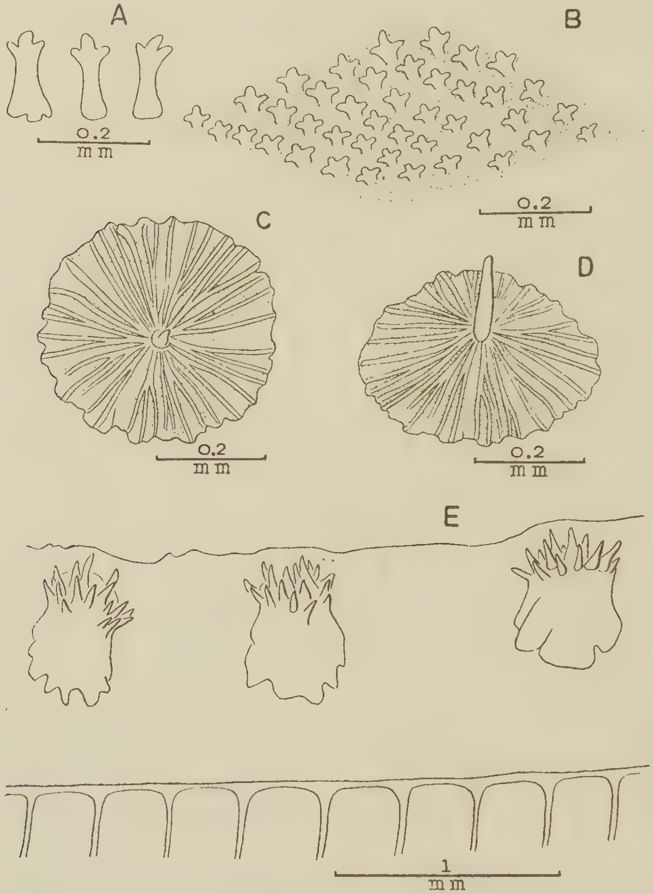


Fig. 11. Teeth on upper jaw (A.B), thumb-tack prickles (C.D) and gill-rakers on lower limb of outer arch (E) in *Liparis tessellatus*. After a male specimen, No. 12744. Drawn by senior author.

prickles bearing enlarged circular basal plates (Fig. 11C·D). The presence of this armature appears to have been overlooked by previous authors. Gill-rakers rather large, tubercular in shape and their distal parts armed with about 10 to 20 pungent prickles (Fig. 11E).

Color variation are rather extensive, though mostly colored like those of the holotype as described and illustrated by GILBERT and BURKE (1912: 356, pl. 41, fig. 3). In some specimens, however, sides of both head and body are furnished

with many fine longitudinal purplish brown bars, which usually disappear after preservation in formalin. In mature males armed with thumb-tack prickles, the ground color of head and body is much darker than in either mature females or youngs.

Remarks:—It can be seen from the above description that the counts and proportions of the holotype of this species given by Gilbert and Burke (1912: 355) are included well within the range of these of our specimens except for the length from anus to front of anal fin, which is more or less longer in our specimens. Most of the proportions of bodily parts show conspicuous variations, attributed, in part, to the inclusion of specimens of widely different sizes, and, in part, to some of our deformed specimens.

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Studies on the Midgut-Gland in Invertebrata IV. Experimental Pathological Observation of the Midgut-Gland in Snail

(With 1 Plate & 1 Table)

TADASHI TSUJII
Faculty of Fisheries, Prefectural University of Mie

Three studies have been reported concerning the midgut-gland in invertebrata (1, 2, 3). This study deals with the observation of the midgut-gland in a snail in which the gland was changed into an abnormal condition by artificial stimulation.

The healthy, or the normal snail, in this study, means the one so well adjusted to its environment that it is capable of carrying on all the functions necessary for its maintence, growth and multiplication with the least expenditure of energy. The diseased snail, or the abnormal snail, means simply the one that is not healthy or normal. In this case, a single cell or organ may be in a pathologic state, not necessarily the entire body. The author's concept of "disease" of a snail is essentially the same as that of other beings, including man.

From this observation, the author has found that a normal condition of a snail can be changed into an abnormal condition by artificial stimulations, and it causes degenerative and progressive changes to be found in the cells of the midgut-gland in invertebrata. The violent degenerative changes occurred in a condition of starvation, and the proliferative changes are found in the specimens injected with a hydrated viscera.

This research was carried out at the Zoological Institute in the Tokyo University of Literature and Science. The author wishes to express his sincere thanks of Prof. S. TAKATSUKI, who gave him kind guidance. Thanks are also due to Dr. O. ICHIKAWA, Chief of the First Division of the Government Experimental Station for Animal Hygiene, and Dr. Y. SAITO, The Kitasato Institute for Infectious Diseases, who gave him valuable suggestions, and to Dr. M. NAKAJIMA, who instructed him in valuable discussions. And the author is very thankful to Prof. Y. OKADA, Dean of this Faculty, who has kindly afforded him the opportunity for the present publication of this paper.

Material and Methods

Snails (*Euhadra sp.*) were used.

a) *The effect of starvation:* Two groups were prepared, each group con-

sisted of four specimens. One group was put in a condition of starvation and the other group was given some food in a glass vessel. These two groups were kept from May 30, 1946 to July 10, 1946; each snail was weighed every day. Some specimens in a condition of starvation were observed from August, 1946 to March, 1947.

b) *The effect of the injection of hydrated viscera:* The alkalic hydrate of of cow's viscera was dissolved in the Linger's solution and a 3% solution of this hydrate was made. The author injected 0.5 cc of the solution into the haemocoels of several specimens once a day, in the caurse of three days. Twenty-four hours after the last injection, the midgut-gland areas were fixed in 10% neutral formalin, absolute alcohol or Champhy's fluid.

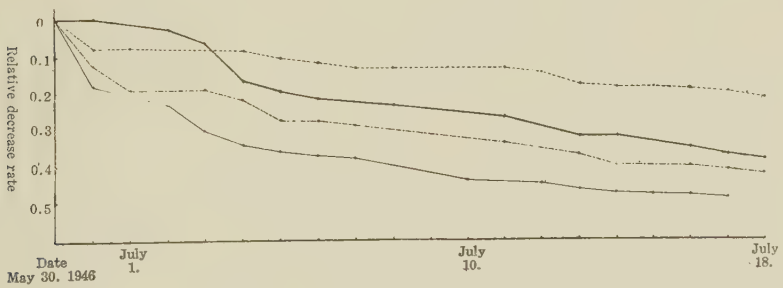
As a control for these experiments, specimens, with no abnormal strain, were fixed as soon as they were collected from the Botanical Garden attached to the Tokyo University.

Embedding and staining methods were done in the same way as that of the previous studies.

Observations

Effect of the starvation: The ones in a condition of starvation made an epiphragm at the mouth of the shell. By this membrane, evaporation of the body water should be reduced. Table I shows the body weight decreasing day after day. After 18 days, the snail were in such a declined state that they could not move. From these phenomena, the author assumes that these snails have changed into an abnormal condition-namely disease.

Table 1. Relative decrease rate of body weight.



The patholigical changes of the several specimens starved from May 30, 1946 to July 10, 1946 resembled those of August, 1946 to May, 1947.

The changes of the so-called enzyme cell: The so-called enzyme cell was atrophied and stained deeply in acidophilic dyes, and its size was about 28μ in length and 4–8μ in breadth. The cytoplasm shows a granulation and also has many vacules, large and small. The distal part of the cytoplasm is secreted into

the lumen, and moreover, many cells are desquamated into the lumen; so these phenomenon indicated a central necrosis (Fig. 2).

The nuclelii are generally rod-like and lay near the basal region, variable in size and positions. Moreover the nucleus shows the karyophyknosis and hyperchromatosis of a nuleus net; and those near the extremity position of the cell, show chromatolysis, nucleushydrops or karyorrexis.

The changes of the so-called lime cell: The so-called lime cells were also strongly atrophied. Their sizes were about 21μ in length and 28μ in breadth. And moreover the cytoplasm decreased in amount and showed vacuolar degeneration. The cytoplasm of the so-called lime cell contained many granules was reticular and stained in basic dyes, and sometimes these granules did not stain in basic dyes but brightly.

A single nucleus, indefinite in shape, lies near the base of the cell. It shows karyolysis, hyperchromatosis of nucleus net, karyophyknosis, or karyorrhexis. The nucleus had, very often, one to three nucleoli. Also there will be recognized a large eosinophilic granule in the cytoplasm (Fig. 3). Sometimes, these granules having the nucleus, look like blood cells, though the blood cells are much smaller than these granules.

The mesenchyme or reticulo-endothelials system existed in the interstitum of the midgut-gland, there also are found an eosinophilic granule, which is much smaller than those in the so-called lime cell (Fig. 3). At the same time, some of the mesenchyme have a great many small granules, colour of which is a grayish brown.

Investigating the preparations that are stained in thionin, the author notices that the metachromatic reaction in the protoplasm of the so-called lime cell is fainter than that in the normal condition. In the cytoplasm of the so-called enzyme cell there appears almost none of the metachromatic reaction. The acidophilic large granules in the cytoplasm of the so-called lime cell did not exhibit any metachromatic reaction. The changes of the mesenchyme, except the changes of the acidophilic or grayish brown granule, are still obscure.

Effect of injection of the hydrated viscera: With the injection of the hydrated viscera most of the specimens became excited, but in a few minutes they moved about quite normally; though a few of the specimens still remained in a state of torpidity, foot and tentacle extended only slightly with limited or no movement. None of the specimens died.

The changes of the so-called enzyme cell: The hypertrophic changes are indicated in the so-called enzyme cell. It size is about 53μ to 93μ in length and 13μ in breadth. The cytoplasm of this cell stained in eosinophile, the distal part of which was secreted into the lumen, and large basophilic granules are in the intermediate part or distal part of the cytoplasm. Its diameter is about 8μ to

15μ, and stained deeply in haematoxylin, and purplish red in thionin and red in pyronin-methylgreen (Fig. 4).

The changes of the so-called lime cell: A single nucleus lies in the base of the so-called lime cell, and it shows, at first, hyperchromatosis of nucleus net, and then shows the karyophyknosis, chromatolysis or karyorrhexis. The hypertrophic changes are also shown by these cells. Its size is about 52μ in length and 13μ in breadth. The cytoplasm is reticular and strongly basophile and seems to be enclosing many large granules. These large granules are stained basophile, and the cytoplasm also stained basophile.

As for the mesenchyme, it had argyrophilic fibres, which were stained by Bielshowsky method, and these fibres showed hyperplasic changes more keenly than the normal ones.

Discussion

The attempt to changes the snail from the normal condition into an abnormal condition proved successful by the artificial stimulation. A few changes have been mentioned, yet the author thinks that there remain still more important changes which are yet obscure.

The starvated individuals lose body weight; their body weight reduced to less than half the initiat weight. And moreover, the so-called lime and enzyme-cells also show atrophic changes. At the same time, these atrophic cells show many visible changes in cytoplasm and in karyoplasm. The vacuolar degeneration of the lime cell may be likened to the primitive cloudy swelling of the liver of vertebrata.

The nucleus shows karyophyknosis, hyperchromatosis of nucleus net, chromatolysis of nucleus net, nucleushydrops and karyorrexis.

In the so-called enzyme cells, the nucleoli can hardly be recognized in the normal and abnormal condition. But in the so-called lime cell, the nucleus can be observed in the both condition. And, especially, the large eosinophilic granules are found in the so-called lime cell in the starvated snail. TAKATSUKI[4)] reported that the amaebocytes are distributed in the pericardial wall cell, renopericardial canal cell and renal tube cell in the oyster. MILLAT[5)] reported that the lining epithelium and subjacent tissues of *Nudibranchs* contain characteristic wandering cells. Although probably amoeboid when alive, after fixation these cells probably come into very definite forms. The wandering cells of *Nudibranchs* are excretory in function taking up an affect matter from the haemocoel to discharge it into the lumen of the gut. But, the results of author show that these eosinophilic granules with basophilic bodies which are found only in the so-called lime cell, and its diameter is much larger than the wandering cells of snails.

Yasui[6] found evidence of the nucleus granules and their reversible swelling nucleoli in plant cells and that these swollen granules finally burst through out of the nucleus. From these facts, the author could assume that the nucleoli of the nucleus in the so-called lime cell begins to enlarge and will burst through out of the nucleus, or are secreted from the nucleus. But, these granules are too large to consider that the nucleoli begins to enlarge and will burst through out of the nucleus.

In the case of the injection of the hydrated viscera, the large basophilic granulea appear in the cytoplasm of the so-called enzyme cell. The same granules were investigated in the normal condition, in secretive stage, but their number in the case of injected specimens was quite larger than that in the normal condition. The causes of formation of these granulea are still undiscovered, though they showed the positive metachromatic reaction in thionin dye.

The mesenchyme or reticulo-endothelial system which existed in the interstitum of midgut-gland, shows the proliferative changes, these changes were stimulated by the injection. From this phenomenon, namely, the author assumes that this interstitial cells is belong the system which stimulate some stimulus. In other words, the phenomenon which is mentioned above may be likened to the reticulo-endothelial system of vertebrata which are activated by some stimulus.

The author could not find any disturbance of the circulatory systems, but he assumes that he cannot well investigate that system because the blood vessels is not so well developed and the blood cells not clearly differentiated.

Summary

From this study, it is clear that a snail in the normal condition can be changed into an abnormal condition by artificial stimulation.

1. With the kind of artificial stimulations, the atrophic changes or the hypertrophic changes accordingly occurred both in the so-called enzyme cell and in the so-called lime cell.

2. The nucleus showed degenerative changes: for example, karyophyknosis, hyperchromatosis of nucleus net, chromatolysis of nucleus net, nucleohydrops and karyorrexis.

3. The cytoplasm of the so-called enzyme cell and of the lime cell decreases in amount and exhibits vasculor degeneration.

4. It is sometimes assumes that the enlarged nucleoli get out of a nucleus or large eosinophilic granule are secreted from a nucleus.

5. When in case of injection of the hydrated viscera, the basophilic large granules appear in the cytoplasm of the so-called enzyme cell.

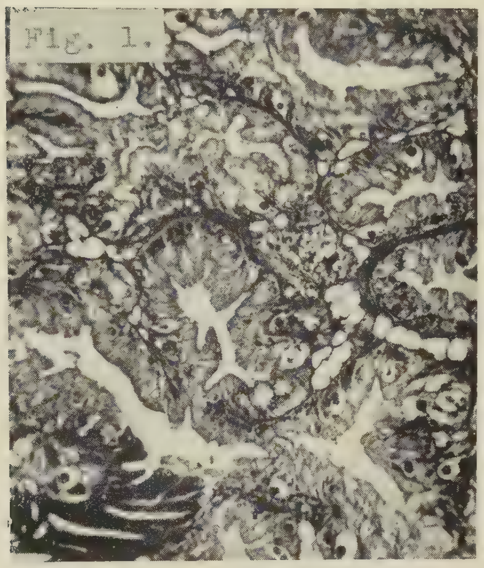
6. The interstitial cells (reticulo-endothelial system) show hyperplasic

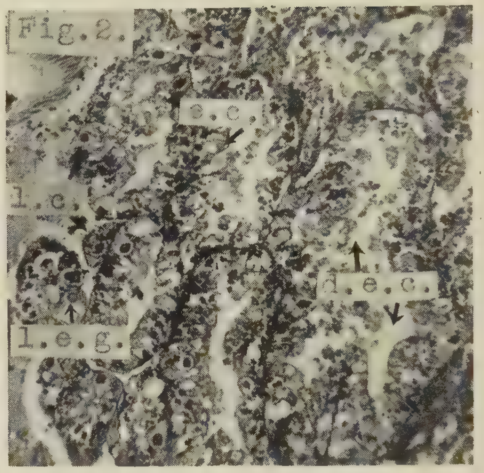
changes with injection of the hydrated viscera.

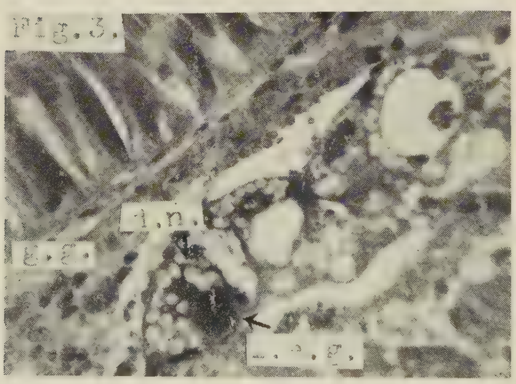
7. The disterbance of circulatory system were not found.

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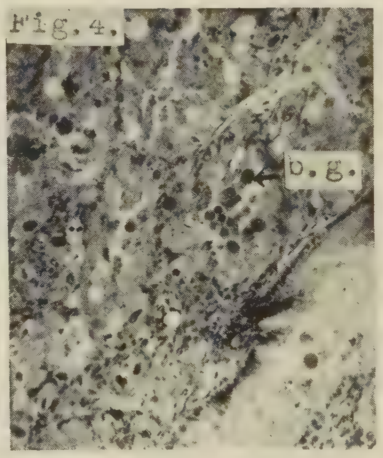


Fig. 1. The midgut-gland in normal snail. Formalin fix. ×100. l.c.: lime cell, e.c.: enzyme cell. Haematoxylin-Eosin stain.

Fig. 2. The midgut-gland of a starved snail. H-E stain. ×100. l.c.: lime cell, l.e.g.: large eosinophilic granule, d.e.c.: enzyme cells which desquamated into the lumen.

Fig. 3. Showing the large eosinophilic granules which were found in the lime cell. H-E stain. ×500. d.n.: degenerative nucleus, l.e.g.: large eosinophilic granule, g.g.: grayish granule in the interstitial cells.

Fig. 4. The midgut-gland in which was injected a hydrated viscera. H-E stain. ×80. b.g.: basophilic granules which secreated from the enzyme cell.

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Vol. 1, No. 3, July 30, 1954

Electron-Microscopic Observations of the Aragonite Crystals on the Surface of Cultured Pearls. I.

(With 1 Plate, 2 Text-figures)

NORIMITSU WATABE
Faculty of Fisheries, Prefectural University of Mie

The surface structures of pearls, or shells, of marine and fresh-water mussels have been observed and reported by BOUTAN (1925), HESSLING (1859), MÖBIS (1858), RÖMER (1903), RUBEL (1911), SCHMIDT (1921), (1923), and other research workes. The present writer (WATABE, 1950) also previously studied cultured pearls and distinguished the volute, parallel, and irregular surface-patterns caused by different modes of aggregation of aragonite crystals. However, the crystals are so small (2–5μ in diameter) that they could not be studied in detail with an optical microscope; so an electron-microscope was used to study the details of these crystals. This paper is concerned with these observations on three pearls.

The writer wishes to express his sincere thanks to Dr. Y. OKADA, Dean of this Faculty, for his kind direction and encouragement. Thanks are also due to Dr. K. OMORI, Professor of Tohoku University, and Dr. R. KIRIYAMA, Professor of Osaka University, who gave the writer kind and useful advice.

Materials and Methods

Pearls

No. 121. Cultured from August, 1951 to March, 1952; Pinkish cream in color with a shiny luster. Under an optical microscope, the surface showed a volute pattern with well-defined crystals along the margin.

No. 122. Cultured from August, 1951 to April, 1952; Pinkish cream in color with a splendent luster. Under an optical microscope, the surface showed a parallel pattern.

No. 123. Cultured in the same period as No. 122; White in color. Under an optical microscope, no distinct pattern was discernible on the surface.

Preparation of specimens

After cleaning the surface of the pearl with alcohol, it was placed on the polymerizing methylmethachryl on a slide glass. After polymerization was accomplished, the pearl was removed. The methylmethachryl, which then bore the imprint of the pearl's surface, was then plated with a thin membrane of aluminum. Thus an aluminum replica of the pearl's surface was obtained and

this replica was electron-micrographed at 50 KV. Direct magnification was ×2000. (Photographs were taken at the Electron-microscopic Laboratory of SHIMAZU-SEISAKUSHO.)

Observations

Pearl No. 121. (Plate-Figure 1 and 2; Text-Figure 1)

As seen in Figure 1, the surface is composed of typical idiomorphic, hexagonal, platy, straightedged aragonite crystals (1–4μ in diameter) and their aggregates. As this photograph was taken horizontally to the quite narrow area (with the radius of about 15μ) of the surface, 001 plane seems to indicate the original shape. Therefore, the angle between the two lines (crystal edges) shows the angle between the two planes joining at right angles to 001 plane with these edges. Measuring these angles, about 116° and 123° were found to be

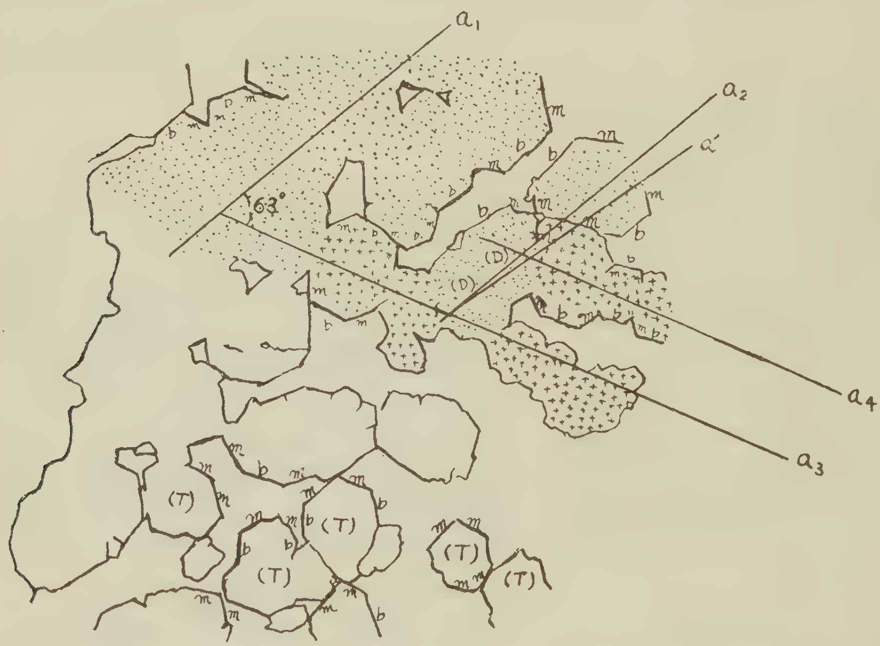


Fig. 1. Showing arrangement of aragonite crystals on the surface of Pearl No. 121. *b*...010 plane. *m*...110 plane. (*T*)...Triple twin. a_1, a_2...Direction of *a*-axis of the crystals in the dotted part. a'...Direction of *a*-axis of the crystals noted with (*D*). a_3, a_4...Direction of *a*-axis of the crystals noted with +.

dominant. Therefore, the dominant planes of aragonite crystals of this pearl are, as in the case of the common platy aragonite, (110), (010), and (001). The presence of these planes is shown in Text-Figure 1.

The 010 planes being thus decided, orientations of the *a*-axes were obtained. Then, it was found that the *a*-axes of the crystals in the dotted part in

Text-Figure 1, have two common orientations, (a_1, or a_2) and (a'), the former being dominant. In the same way, those crystals in the part noted with + have their a-axes oriented equally either as a_3, or as a_4. The presence of these common directions shows that the crystals in each part developed by parallel growth.

Judging from this fact, and in addition, that the intercepting angles of a_1 and a_3, and a_2 and a_4 are equal (about 63°), and, further, from the branch-like shape of the whole view, this surface must have been formed by the dendritic growth of aragonite crystals.

As the main stem will probably be a_1, the crystallization must have taken place in the direction of the volute line of the surface. Strictly speaking, as described before, the orientation of the a-axes in the dotted part is not uniform, but expressed in two lines a_1 (or a_2) and a', so the aggregates do not show the parallelism. This is often seen in the dendritic growth. According to Buckley (1951), a slight disturbance may cause fracture of the dendritic limb, and this will lean at a slight angle to the rest. When the large crystals grow on such a bruised dendrite, they show the slightly deviated parallelism. The deviated crystals are shown in Text-Figure 1 with the notation of "*D*".

Secondly, triple-twins (*T*) can be seen. Three types of triple-twins may appear in aragonite aggregates, and all of these types appear in the photograph.

Papapetrov (1935) stated, when the solution is in the higher supersaturated condition, that is, in the labile condition, the rate of the crystal growth and the rate of the dispersion of the solvent come to be unbalanced, and this results in the formation of the dendrite. Twins, too, result from the labile condition of the solution.

From these facts, it seems that the surface of this pearl has been formed from a highly supersaturated solution of $CaCO_3$.

As the surfaces of the crystals are quite even, and the crystals are well shaped, this part of the surface shows the final stage of the crystal growth of aragonite. This is the type of surface most commonly seen in pearls.

But another part of the same specimen shows a quite different view. As seen in Plate-Figure 2, though the surface is even and the mode of the aggregation of the crystals looks like that of Figure 1, the margins of the crystals are eroded. This figure shows that the crystals are dissolving. Examples of dissolving crystals can be seen more clearly on pearl No. 122, and most clearly on pearl No. 123.

Pearl No. 122. (Plate-Figure 3 and 4; Text-Figure 2)

Figure 3 shows that this surface is composed of rather rounded, semimorphic, aragonite crystals (1–5μ in size) and their aggregates. The aggregates indicate a different arrangement from that of pearl No. 121. This must have

been caused by the irregular growth of the aragonite, as there is no regularity in the aggregates. Any other planes than (001) could hardly been decided, as these crystals show semimorphic forms.

In Figure 4, taken at another part of the same specimen, vicinal faces (*V*), and small rounded hill-rocks (*H*) are seen. MIERS (1903) found that vicinal faces appear at an early stage of the dissolution, and rounded hill-rocks, too, are formed by dissolution. On the other hand, BORGSTRÖM (1911) and others reported that the rounded (curved) faces are often formed by the presence of impurities in the solution. Rounded hill-rocks often appear in many growing crystals. The presence of the vicinal faces is not rare.

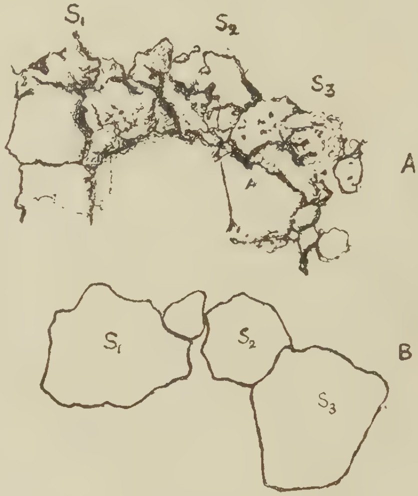


Fig. 2. Showing the dissolving crystals (A), and their original forms (B), in the Pearl No. 122.

S_1 and S_3...Half part dissolving.
S_2...Center dissolving.

But, in the present case, half part, or inner part of the crystals are destroyed. ("*S*" in Plate-Figure 4.) (Sketches of the destroyed crystals and their original forms are shown in Text-Figure 2.)

By these facts, the surface crystals in Figure 4 are considered to be partially dissolved.

Pearl No. 123. (Plate-Figure 5 and 6)

The surface of this pearl is composed of the aggregates of numerous fine nuclei of aragonite crystals (Figure 5), and no large, well-shaped crystals are observed. This figure may indicate the first stage of the crystallization of aragonite.

Exmaples of partially dissolved crystals can be seen clearly in other parts of the same specimen (Figure 6).

WATANABE (1950) and the present writer (WATABE, 1950) found that a nacreous layer of a cultured pearl is not formed evenly over the whole entire surface at one time, but is formed locally by the local crystallization of aragonite.

Their findings will be supported by the electron-micrographs which indicate that the surface arrangement is not uniform, even in the same pearl.

Further, the partially dissolved crystals shown in the photographs will be a proof for the idea of pearl formation, which was reported by the present writer (WATABE, 1951, 1952), that the nacreous layer is formed not merely by the crystallization of aragonite, but by the repeated growing and partially dissolving, that is, crystallization, partial dissolution, and recrystallization.

Summary

1. The surface of three cultured pearls were electron-micrographed.

Pearl No. 121:—the surface was formed by parallel dendritic growth of aragonite crystals with hexagonal idiomorphic forms. Triple-twins could be observed.

Pearl No. 122:—the surface was formed by the irregular growth of aragonite crystals with rounded semimorphic forms.

Pearl No. 123:—the surface was composed of the aggregates of the fine nuclei of aragonite crystals.

2. The dissolving figure could be observed in all of these pearls.

This will prove the writer's idea of pearl formation that the nacreous layer of pearls are formed by the repeated crystallization, partial dissolution and recrystallization.

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Explanation of Plate IV

Electron-microphotographs of the surface of cultured pearls. (×3000)

Fig. 1. Pearl No. 121. Showing parallel and dendritic growth of aragonite crystals.

Fig. 2. Pearl No. 121. Margin of crystals are dissolving.

Fig. 3. Pearl No. 122. Showing irregular growth of aragonite crystals. Crystal faces are curved.

Fig. 4. Pearl No. 122. Crystals are dissolving. S—Crystals half dissolved. H-rounded hill-rocks. V—Vicinal faces.

Fig. 5. Pearl No. 123. Showing the aggregate of fine nuclei of aragonite crystals.

Fig. 6. Pearl No. 123. Crystals are dissolving.

Fig. 1 and 2, 3 and 4, 5 and 6, were taken at the different part of the same specimens, respectively.

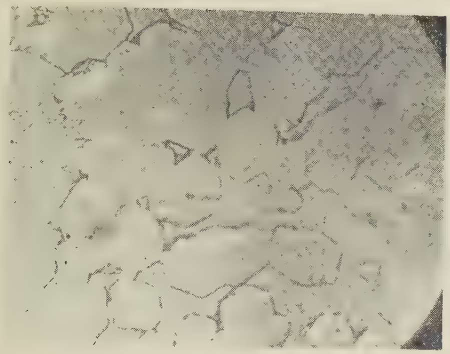


Fig. 1

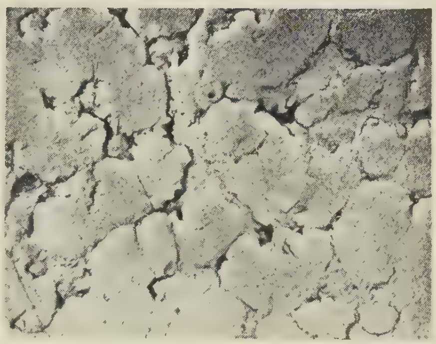


Fig. 2

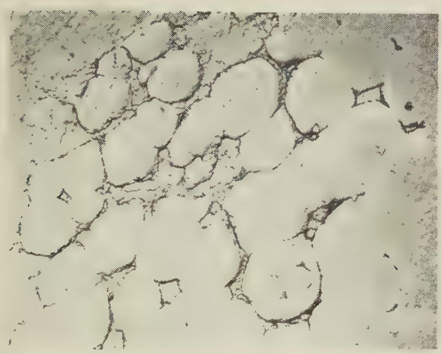


Fig. 3

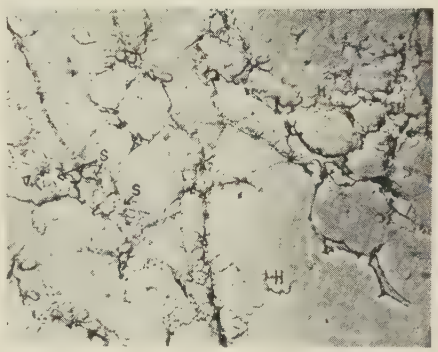


Fig. 4

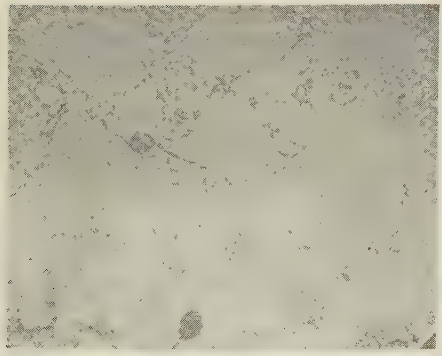


Fig. 5

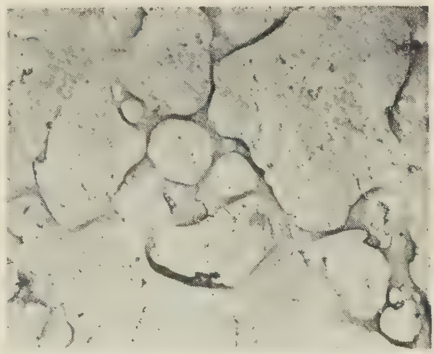


Fig. 6

WATABE—Electron-microscopic Observations of Aragonite Crystals on the Surface of the Cultured Pearls.

Report of Faculty of Fisheries,
Prefectural University of Mie,
Vol. 1, No. 3, July 30, 1954.

Studies on Vitamin B_6 in Marine Products I. The Content of Vitamin B_6 in Marine Fish

(With 1 Text-figure & 4 Tables)

Masato MIYAKE and Koichiro HAYASHI
Faculty of Fisheries, Prefectural University of Mie

A few investigations have been made on vitamin B_6 in natural materials[1][2] and few estimations been done in marine products[1][3][4].

As to the determination of vitamin B_6, there are chemical, microbiological, and animal methods. Of these methods, the chemical one has some faults non-characteristic for each kind of B_6 group and therefore a careful purification is required. Previously the authors[5] have carried on the estimation of B_6 in aquatic animals, improving the Ryu's method[6] which is based on diazo reaction, but they also had some doubts whether this method was available.

Now the authors adopted the microbiological method and estimated the total amount of B_6 in marine fish with the following results.

Experiments

Method for Determination of Vitamin B_6:

Vitamin B_6 was determined with the yeast Saccharomyces carlsbergensis, as described by Atkin[2].

Preparation of Samples for Assay:

The fish organs were dissected from fish body and homogenized. A portion about 0·5–1 g. weight of above homogenized material was suspended in 180 ml. of 0.055 N sulfuric acid in a erlenmeyer flask of 300 ml., and heated in an autoclave at 20 pounds pressure for 5 hours, then cooled, neutralized to pH 7.0 and diluted for estimation.

Basal Medium:

The components of basal medium are shown in Table 1.

Table 1 Components of the basal medium (1L.)

Dextrose	100 g.	$FeCl_3 \cdot 6H_2O$	5 mg.	Thiamine HCl	500 γ
KH_2PO_4	1.1 g.	$MnSO_4 \cdot nH_2O$	5 mg.	Biotin	16 γ
$CaCl_2 \cdot 2H_2O$	250 mg.	K-citrate	10 g.	Inositol	50 mg.
$MgSO_4 \cdot 7H_2O$	250 mg.	Citric acid	2 g.	Ca-pantothenate	5 mg.
10% vitamin free casein hydrolyzate 80 cc.					

Individual solution of the various components of the basal medium prepared

previously was combined before use and 5.0 ml. of the mixture was placed in a series of test tubes of 18 mm. in diameter and 180 mm. in length. 4.0 ml. of sample of various dilution was added to it and steamed for 10 minutes at 100°C. in a Koch, cooled, and inoculated the yeast.

Yeast Inoculum;

Sacch. carlsbergensis 4228 was inoculated as a preculture on agar slants of pH 6.8–7.0, composed of 5% of yeast extract, 1% of peptone, 1% of dextrose, and 2% of agar. A slant was incubated for 18–24 hours at 30°. A quantity of fresh growth was removed by a sterile wire loop and suspended in 10 ml. of sterile 0.9 per cent saline in a colorimeter tube and the concentration of yeast was measured using the curve between the weight of the yeast and the transmissivity. And then the suspension was adjusted to a concentration of 0.1 mg. of moist yeast per ml. with additional sterile saline. 1.0 ml. of the adjusted suspension was then added sterilely to 9.0 ml. of culture solution and the volume was made to 10 ml. The final suspension thus obtained contained 10γ of moist yeast per ml.

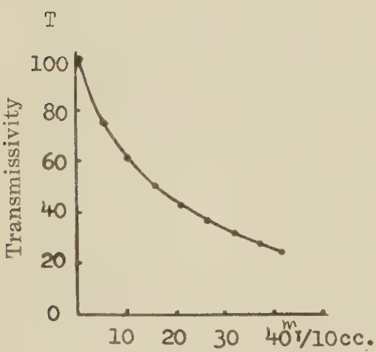


Fig. 1. Standard curve of pyridoxamine

Culture:

The tubes was shaken at the velocity 90r./min. at 30° for 18 hours and then steamed for 5 minutes in a Koch.

Estimation:

The turbidity of the yeast was measured by photoelectric meter at 550 mμ. and estimated the B_6 content in sample from the standard curve of B_6 (Fig. 1) previously prepared.

The responses of Sacch. carlsbergensis to pyridoxal, pyridoxamine, and pyridoxal are not exactly the same. The results obtained by several workers and the authors are shown in Table 2. It is expected from the table that the estimated value of the

Table 2 The relative activities of B_6 group for S. carlsbergensis

Pyridoxine	1.0	1.0	1.0
Pyridoxal	1.0	1.3	1.25
Pyridoxamine	1.0	1.2	1.2
Investigator	SNELL[7]	RABINOWITZ[8]	Authors

experiments varies with the sort of B_6 used as a standard. The total amount of B_6 in fish, determined with Sacch. carlsbergensis, was expressed as pyridoxamine hydrochloride in our experiments, since it has been reported by RABINOWITZ and SNELL[1] that the greater portion of vitamin B_6 in animal sources was present as pyridoxamine.

Table 3 Recovery of pyridoxamine hydrochloride

Sample meat	B_6 content (γ)	Pyridoxamine added (γ)	Total B_6 (γ)	Recovery (%)
Saurida argyrophanes (Eso)	16.2	5	20.6	88.0
Decapterus muroadsi (Muroaji)	14.6	5	19.4	98.0
Limanda angustirostris (Karei)	15.0	5	20.5	110.0

Table 4 Contents of B_6 in various fish

Sample	In fresh matter γ/g.	In dry matter γ/g.	Sample	In fresh matter γ/g.	In dry matter γ/g.
Auxis thazard (Soda-katsuo)			*Mugil cephalus* (Bora)		
Common meat	9.26	34.9	Common meat	3.60	15.4
Dark color meat	5.58	20.4	*Saurida argyrophanes* (Eso)		
Heart	6.70	31.4	Common meat	10.1	41.4
Liver	26.3	75.3	Liver	11.8	32.3
Sardinia melanosticta (Maiwashi)			Ovary	4.21	21.7
Common meat	9.58	34.5	*Muraenesox cinereus* (Hamo)		
Viscera	3.49	10.8	Common meat	1.80	8.8
Etrumeus micropus (Urume-iwashi)			Liver	13.30	46.5
Common meat	7.88	30.7	Ovary	3.26	15.1
Viscera	4.87	14.3	Intestine	1.27	4.7
Scomber tapeinocephalus (Goma-saba)			*Limanda angustirostris* (Karei)		
Common meat	14.0	54.7	Common meat	1.70	8.0
Dark color meat	10.05	34.8	Liver	4.28	10.8
Liver	25.9	79.5	Ovary	1.62	8.1
Pyloric appendix	1.10	3.2	*Zenopsis nebulosa* (Kagamidai)		
Cololabis saira (Samma)			Common meat	2.20	10.4
Common meat	12.5	47.5	Liver	10.0	49.4
Viscera	8.06	19.8	*Fistularia petimba* (Yagara)		
Scomber japonicus (Saba)			Common meat	1.92	9.6
Common meat	12.5	49.2	Liver	11.9	51.9
Liver	21.5	62.2	*Labracoglossa argentiventris* (Takabe)		
Pyloric appendix	3.74	15.5	Common meat	1.72	7.9
Decapterus muroadsi (Muroaji)			*Scombrops boöps* (Mutsu)		
Common meat	10.15	39.2	Common meat	0.47	2.5
Liver	16.35	49.3	*Lateokbrax japonicus* (Seigo)		
Hexagrammos otakii (Ainame)			Common meat	2.28	12.1
Common meat	1.04	6.1			
Acanthogobius flavimanus (Mahaze)					
Common meat	1.23	6.1			

Recovery test: It is said that the error of about 10 per cent is accompanied with the microbiological assay for the determination of B_6 in natural materials. Recoveries of pyridoxamine hydrochloride are shown in Table 3. Examination of the assay values shows that the recoveries in this experiment are good on the whole.

Results and Discussion

Samples used for assay were obtained in fresh conditions at the Tsu Fisheries Market from the beginning to the middle of October, 1953. The results are shown in Table 4. The red meat fish contained more than 30γ/g. of B_6 in dry matters of fish meats, while the white meat fish contained about 10γ/g. or less. It seemed poor in dark colored meat compared with common meat. The amount of B_6 in liver of red meat fish, equally in that of white, was more than 45γ/g., showing much quantity than in red fish meat. In the other organs small amount of B_6 was detected, especially very little in pyloric appendix. In the same kind of fish it is assumed that the content of B_6 varies according to season, age, environment, freshness, and degree of sexual maturity. Further investigations on these points and the estimation of each kind of B_6 group should be carried on, and the latter investigation will show whether the adoption of pyridoxamine as a standard for the calculation of the whole amount of B_6 group was suitable.

Summary

1. Total amount of B_6 in various organs of fish was estimated by the microbiological method of ATKIN.

2. The meat of red meat fish contained much B_6 than that of whites.

3. Amongst the organs the liver contained most in all cases and its content was nearly equal in red and white meat fish.

We wish to express our thanks to Mr. HARA (Research Institute, Ministry of Agr. and Forest.) for kindly supplying the yeast for this study. We are also indebted to Mr. MATSUBARA for his assistance in carrying out the experiments.

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